JOURNAL OF DAIRY SCIENCE

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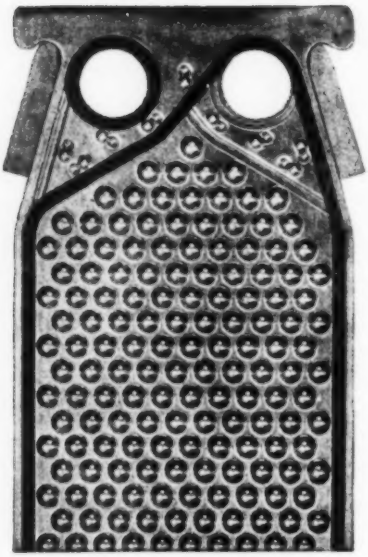

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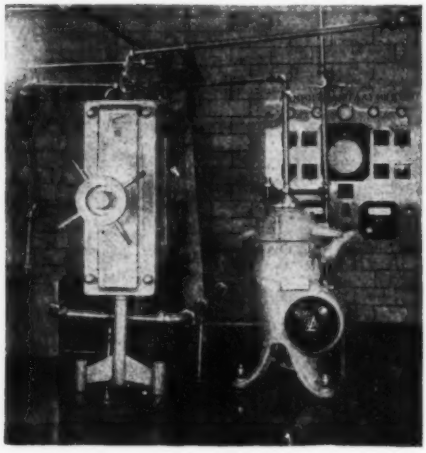

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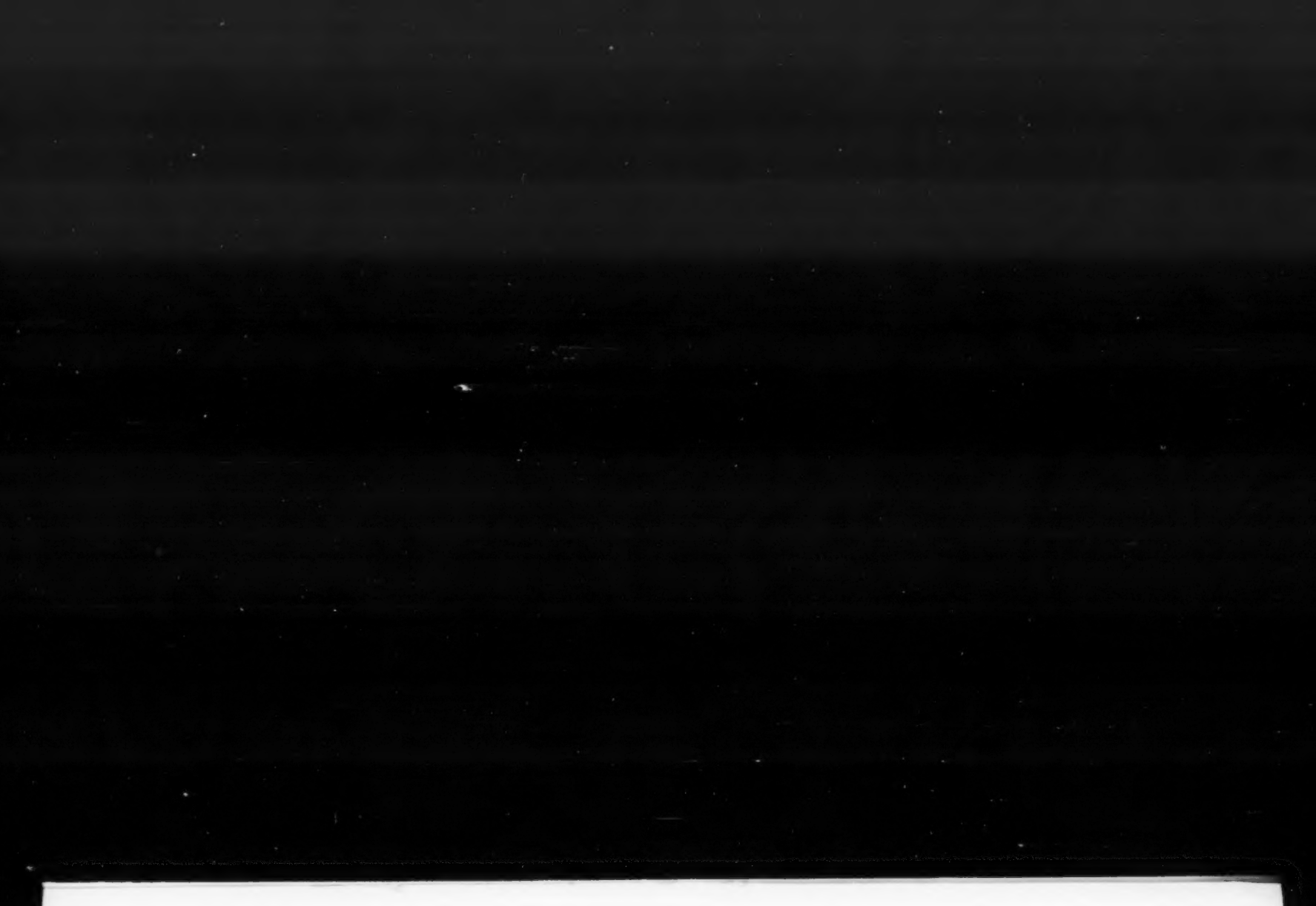

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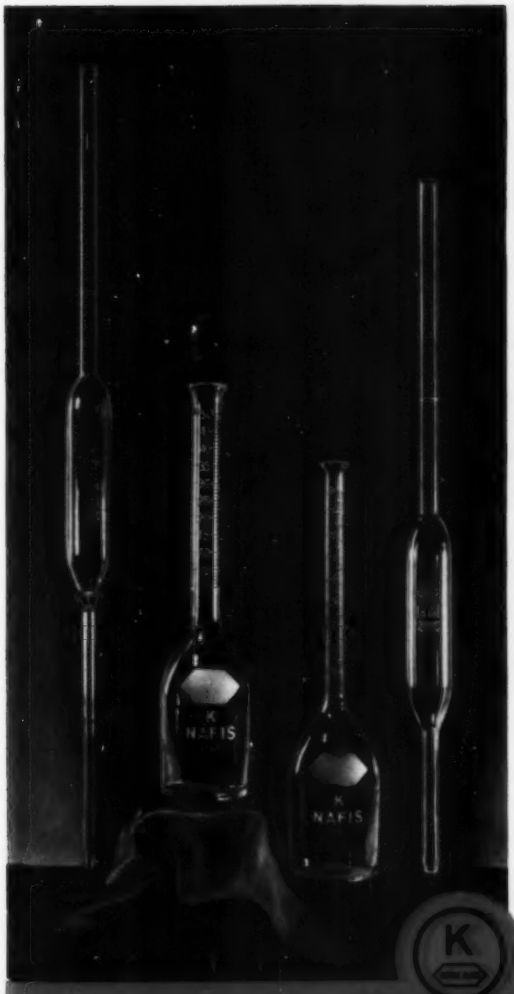

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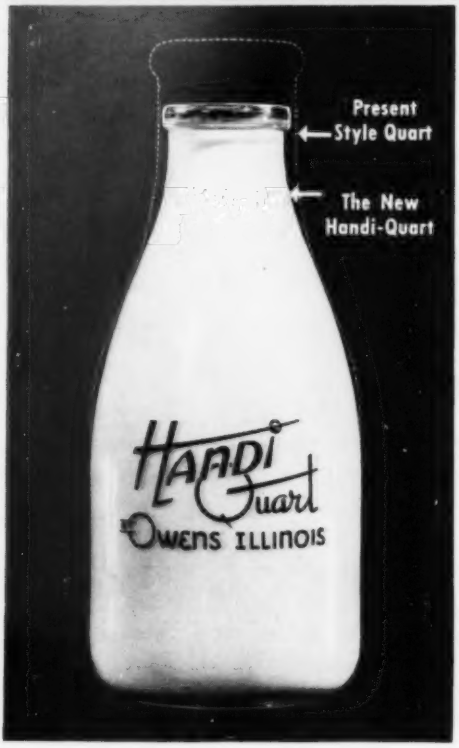

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JOURNAL OF DAIRY SCIENCE

VOLUME XXIV DECEMBER, 1941 NUMBER 12

FACTORS AFFECTING THE GAS CONTENT OF MILK[1]

C. I. NOLL AND G. C. SUPPLEE

Borden Biological and Chemical Research Laboratories, Bainbridge, New York

The presence of oxygen, nitrogen and carbon dioxide as dissolved gases in milk has long been recognized. However, few papers have appeared on this subject since the studies of Marshall in 1902 (1). Most of the data published since that time have been primarily concerned with the effect of oxygen on milk constituents and the consumption of oxygen by bacteria. Little direct attention has been given to the effect of physical factors, temperature, pressure and light, and chemicals, on the gas content of milk. A systematic study of these factors as operative in the routine handling of milk and as a basis for potential improvement in operating practices has appeared desirable.

Before presenting experimental data, a brief review of the earlier work seems appropriate. The gas content of anaerobically drawn milk reported by Marshall (1), Van Slyke (2), Jackson (3), Frayer (4) and others, is summarized in table 1. (Recalculation of the original data to the volume per cent basis, that is volume of gas at 0° C., 760-mm. pressure per 100 ml. of milk has been made to facilitate interpretation and comparison.) It should be noted that the gas remaining after the absorption of oxygen and carbon dioxide, is called nitrogen by most of the investigators. This convention is used throughout the present work, but it is recognized that this

TABLE 1

Gas content of anaerobically drawn milk

Investigator	Oxygen	Nitrogen	Carbon dioxide	Total gas
	vol. %	*vol. %*	*vol. %*	*vol. %*
Hoppe*	0.14	1.37	1.65	3.00
Setchenow*	0.17–0.32	1.33–1.41	5.00– 6.71	6.67–8.29
Pfluger*	0.09–0.10	0.71–1.00	7.40– 7.66	8.47–8.49
Marshall	0.12–0.14	0.82–1.02	3.44– 4.96	4.40–6.10
Van Slyke	.....	.....	8.00–56.00	.....
Jackson	.....	.....	25.80–28.70	.....
Frayer	0.092	1.184	6.577	7.853

* Quoted by Marshall.

Received for publication June 30, 1941.

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may not be pure nitrogen since methane, ammonia and hydrogen may also be present; the nitrogen content could also be called "residual gas."

The change in the gas content of milk immediately upon contact with air, as in the milking process, is indicated by the data summarized in table 2. (Compare with table 1.) These results indicate a drop in the carbon dioxide content and an increase in the oxygen and nitrogen contents.

TABLE 2

Gas content of milk immediately after milking

Investigator	Oxygen	Nitrogen	Carbon dioxide	Total gas
	vol. %	*vol. %*	*vol. %*	*vol. %*
Thorner*	0.36–0.44	1.82–1.87	3.57–6.25	5.70–8.56
Marshall	0.86	1.71–2.19	2.93–3.78	5.50–6.84

* Quoted by Marshall.

Marshall (1) has shown that the oxygen and nitrogen content of milk may be increased to 1.15 and 2.47 volume per cent respectively, by aeration methods. The work of Van Slyke (2) has indicated that one-third of the carbon dioxide in milk exists as carbonic acid and two-thirds as bicarbonate. Jackson (3) has presented data indicating the carbon dioxide content of anaerobically drawn milk to be 25 to 28 volume per cent, which is approximately one-half that of blood plasma. He points out that this ratio compares well with the ratio between the total sodium and potassium in blood plasma and milk, and concludes that these elements are the principle binders of carbon dioxide in milk.

Sharp, Guthrie and associates (5, 6, 7) have shown a relationship between the oxygen content of milk, the development of oxidized flavor and the destruction of ascorbic acid; likewise, various data have been presented showing the oxygen content of milk throughout different phases of commercial handling and processing. A comprehensive report by Frayer (4) has correlated a decrease in the dissolved oxygen content of milk and an increase in the carbon dioxide content with increases in bacterial count; he also noted that the dissolved oxygen content of milk rapidly decreased when milk was exposed to sunlight.

While both Sharp and Frayer have shown the general effect of temperature on the gas content of milk, one of the objects of this paper is to show the direct relation between the amount of dissolved gas in milk, particularly oxygen, and the physical principles governing the solubility of a gas in a liquid. According to these principles, at constant pressure the solubility of a gas in a liquid is inversely proportional to the temperature.

EXPERIMENTAL

Since the plan of the work reported herein involved the correlation of analytical values for dissolved oxygen, nitrogen and carbon dioxide in milk

subjected to controlled physical treatment, the selection and adaptation of appropriate methods of analysis was of importance. The manometric procedure and calculation of results described by Van Slyke and Neill (8) for the successive determination of carbon dioxide, oxygen and nitrogen in blood, were employed throughout the work, with the exception that lactic acid was used for liberating carbon dioxide in lieu of sulfuric acid. An extended series of preliminary analyses showed that values for each of the gases determined on duplicate samples of milk readily checked well within 0.05 volume per cent.

The typical gas content of mixed milk as sampled from a reservoir conjoined with the usual piping, to the receiving vat in a commercial milk plant is shown in table 3; these results were accumulated over a period of several months. The results are in good agreement with those obtained by Sharp (7) and Frayer (4) from similar commercial milk (summarized in table 4) and should serve as adequate evidence concerning the normal gas content of milk as received by commercial milk handling establishments. In comparing these results with those in table 1, it is apparent that the oxygen and nitrogen contents are higher than those for anaerobically drawn milk, whereas the carbon dioxide content is lower; they are of the same order of magnitude as those shown to prevail immediately after milking (table 2).

TABLE 3

Gas content of mixed raw milk as received at a commercial milk plant

Sample No.	Oxygen	Nitrogen	Carbon dioxide	Total gas
	vol. %	*vol. %*	*vol. %*	*vol. %*
1c	0.48	1.32	4.02	5.82
56c	0.45	1.24	3.73	5.42
20c	0.59	1.38	4.07	6.04
44c	0.51	1.27	4.71	6.49
90c	0.45	1.18	4.30	5.93
108c	0.51	1.22	6.28	8.01
121c	0.54	1.26	3.95	5.75
145c	0.43	1.32	4.88	6.63
153c	0.51	1.35	4.74	6.60
196c	0.36	1.24	4.49	6.09
Minimum (63 samples)	0.30	1.18	3.44	4.92
Maximum (63 samples)	0.59	1.63	6.28	8.50
Average (63 samples)	0.47	1.29	4.45	6.21

It is apparent that oxygen and nitrogen are rapidly absorbed by milk upon exposure to air even as prevails during milking, with the consequent result that the amount of these two gases dissolved in milk at the time it reaches the processing plant is markedly different and higher than when drawn. The average value of 0.47 volume per cent oxygen found in com-

TABLE 4

Summarized comparison of the gas content of raw commercial mixed milk

Investigator	Oxygen (vol. %)			Nitrogen (vol. %)			Carbon dioxide (vol. %)		
	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.
Sharp	0.51	0.47	0.49	.....	.....	.....	.....	.....	.....
Frayer	0.74	0.20	0.43	1.48	1.17	1.37	4.50	2.78	3.63
Authors	0.59	0.30	0.47	1.63	1.18	1.29	6.28	3.44	4.45

mercial milk at an average temperature of about 15° C. is quite comparable to the value of 0.52 volume per cent found in stored distilled water at 24° C. It may be assumed, therefore, that a state of equilibrium in milk is approached and seemingly reaches consummation fairly rapidly. Critical values for the ratio of oxygen to nitrogen dissolved in water in equilibrium with air are 33.9 : 66.1. The ratio of oxygen to nitrogen calculated from the average values for milk as recorded above is 26.7 : 73.3, assuming the "residual gas" is entirely composed of nitrogen. This ratio would undoubtedly more closely approach the equilibrium ratio for water if the methods of analysis permitted a segregation of the values for true dissolved nitrogen and other possible constituents of the "residual gas," such as traces of ammonia, known to be present in fresh milk. These considerations would tend to give high "nitrogen" values. Likewise, it is probable that oxidation of certain milk components is initiated in the presence of dissolved oxygen and progresses continuously from the time the milk is drawn and proceeds concurrently with absorption of oxygen from the air. This contingency would tend to cause a lag in the oxygen equilibrium in milk as compared with water. These relationships exemplify the operativeness of well known physical principles governing the amount of dissolved oxygen in milk, and bring into bold relief the basic character of the problems involved in practical methods for the elimination or control of the oxygen content of milk as handled and processed under practical conditions.

THE EFFECT OF TEMPERATURE

The influence of different heat treating methods on the gas content of raw commercial mixed milk may be illustrated by the results obtained from short time-high temperature pasteurization equipment if provision is made for securing valid samples. The Trumbull Electro-Pure apparatus and the Flowing Film Electric Pasteurizer described by Supplee and Jensen (9) were used for obtaining data of this character. Milk samples from the Electro-Pure apparatus operated at different temperatures were collected in an atmosphere of nitrogen from a by-pass at the top of the heating unit without previous cooling. Notwithstanding rigid control of the method for obtaining completely filled sample containers, and appropriate sealing prior

to analysis, the momentary exposure of the hot milk to an atmosphere of nitrogen presumably permits some of the dissolved gases to escape. The results summarized in table 5 are averages of several determinations which show the effect of temperatures from 162° F. to 190° F. on the gas content of milk treated in this particular type of apparatus operated without the heat regenerator. The values for the oxygen content plotted against the pasteurization temperature are shown graphically in figure 1. The zero value for 212° F. is necessarily included as a point of reference. The straight line relationship shown by these data is in conformity with critical reference data for the solubility of oxygen in water over the same temperature range, thus confirming the general law governing the solubility of gases in a liquid as affected by temperature.

TABLE 5

Gas content of hot milk samples taken from an electro-pure pasteurizer immediately after pasteurization at various temperatures

Pasteurization temperature	Oxygen	Nitrogen	Carbon dioxide
° F.	*vol. %*	*vol. %*	*vol. %*
162	0.35	1.05	4.48
175	0.24	0.92	4.22
185	0.18	0.78	4.02
190	0.10	0.71	4.63

Further studies on the gas content of milk treated in the Electro-Pure Apparatus were carried out with the technique just described, but with the

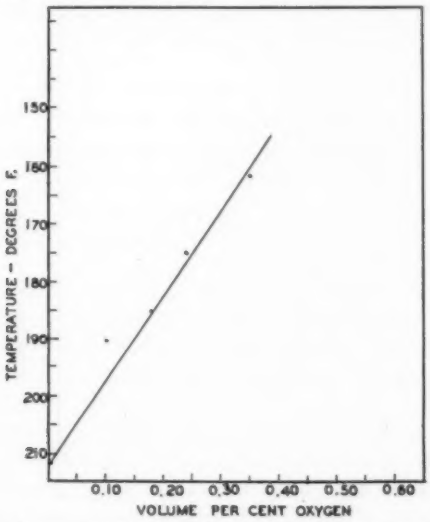

FIG. 1. Dissolved oxygen in hot milk direct from electro pure apparatus.

exception that all milks were pasteurized at 195° F. and subsequently cooled to 100° F. in an internal spiral condenser under conditions which permitted heating and subsequent cooling in a completely closed system. The data, summarized in table 6, show an average oxygen content of 0.23 volume per cent as compared with 0.10 volume per cent for the hot milk pasteurized at 190° F. but not subsequently cooled (table 5). The nitrogen content of the cooled milk is likewise significantly higher than was found in the hot milk at the same comparable pasteurization temperature. Since the collection and sealing of the samples for both series of determinations were carried out under the same rigidly controlled conditions, the lower oxygen and nitrogen values found in the hot milk momentarily exposed to nitrogen during collection of the samples, are interpreted as being due to the fact that the gas dissolved in the hot milk was dispelled immediately upon release from the closed system, whereas the hot milk subsequently cooled in a closed system could not dissipate the gas at the higher temperature.

TABLE 6

Gas content of milk pasteurized at 195° F. with an electro-pure pasteurizer and cooled to 100° F. in a closed system

Run No.	Oxygen	Nitrogen	Carbon dioxide
	vol. %	*vol. %*	*vol. %*
1	0.26	0.88	4.48
2	0.19	1.08	4.75
3	0.24	0.89	4.65
4	0.19	0.89	4.60
5	0.25	0.91	3.67
Average	0.23	0.93	4.43
Average of unheated samples	0.44	1.33	5.02

The gas content of milk as affected by treatment at 185° F. and subsequent cooling in air with the Supplee-Jensen equipment, is shown in the data summarized in table 7. These results were obtained from milk fed to the apparatus from an internal preheater, the milk going to the heating unit at 90° F. Samples for gas analysis were taken from the storage tank ahead of the preheater, as the milk left the heating unit at 185° F., and upon leaving the cooler at a temperature of 50° F. The results show substantially a 50 per cent decrease in oxygen content of the hot milk; an average value of 0.26 volume per cent as compared with 0.48 volume per cent in the raw milk, and a reabsorption on cooling in air to 0.35 volume per cent or about three-fourths of the amount originally present in the unheated milk. It will be noted that the oxygen content of the hot milk as it left the heating unit is substantially the same as that for the milk heated and cooled in the closed system (Electro-Pure Apparatus, table 6). Since the maximum heating temperature in both instances was of the same order of magnitude, 195° F.

and 185° F., the data are of particular interest in further correlating oxygen content of the milk with its temperature. However, the data presented in table 7 indicate rapid reabsorption of oxygen upon exposure to air at lower temperatures, as during cooling in ordinary atmosphere.

TABLE 7

Gas content of milk samples taken from a flowing film pasteurizer
(Flow rate—5 oz. per inch per minute)

Samples from	Milk temp.	Oxygen	Nitrogen	Carbon dioxide
	° F.	*vol. %*	*vol. %*	*vol. %*
Feed tank	68	0.48	1.28	3.98
Heating unit	185	0.26	0.65	2.45
Cooler	50	0.35	0.93	2.13

Comparing the foregoing results with those reported by Sharp (7) and Frayer (4) for the holding method of pasteurization (table 8) it will be noted that the oxygen content of the hot milk is of the order of magnitude which might be anticipated from the temperature (144° F.) to which the milk is subjected. Cooling to a low temperature over an external cooler causes reabsorption of oxygen to substantially the same, or possibly a higher level than has been reported for average unprocessed raw milk. The results reported herein and those recorded by Frayer show a drop in the carbon dioxide content of milk on heating, and a further decrease on cooling in air. This is readily understandable in view of the fact that the amount of carbon dioxide in the atmosphere under ordinary conditions is extremely small and accordingly its partial pressure is substantially below that required for saturation of the milk.

TABLE 8

Gas content of milk during the holding process of pasteurization (144° F.)

Origin of samples	Reported by Sharp	Reparted by Frayer		Carbon dioxide
	Oxygen	Oxygen	Nitrogen	
	vol. %	*vol. %*	*vol. %*	*vol. %*
Before heating	0.77	0.557	1.287	3.944
Beginning of holding period	0.39	0.493	1.156	3.944
End of holding period	0.32	0.395	1.075	3.814
Bottom of external cooler (40–47° F.)	0.55	0.522	1.019	2.337

THE EFFECT OF PRESSURE

It is common knowledge that by increasing the pressure of a gas over a solution the weight of the dissolved gas in the solution is increased; this is expressed quantitatively by Henry's Law for the solubility of gases in liquids. The experimental procedures used in studying the effect of pres-

sure on the gas content of milk were adapted for comparing methods for the removal of dissolved gas, particularly oxygen. The most general procedure for the removal of gases from liquids involving the application of pressure principles, is to subject the liquid to a vacuum treatment. Other methods may be described as displacement procedures based on the removal of a particular gas by flushing with a different gas. Specific data involving each of these methods as applied to milk, singly or in combination, are presented hereinafter. Specimen data showing the rate and degree of reabsorption of gases by deaerated or deoxygenated milk as influenced by the pressure of the gas above the solution are also presented.

It has been shown previously that raw commercial milk contains substantially 0.47, 1.29 and 4.45 volume per cent respectively of oxygen, nitrogen and carbon dioxide (table 3); these ratios representing approximate equilibrium with the partial pressure of the oxygen and nitrogen in the air over the milk. Such milk may be substantially completely deoxygenated and its nitrogen and carbon dioxide contents markedly reduced by vacuum treatment applied in two different ways, which will be designated as methods 1 and 2.

Method 1 involved heating milk to 185° F. and rapidly cooling to 100° F. with the Flowing Film Electric Pasteurizer to which reference has previously been made (9), the heating and cooling being carried out in an atmosphere of nitrogen. The treated milk was passed directly without exposure to air into an appropriate receptacle maintained at 24 to 29 inches vacuum. Method 2 involved deaeration with the apparatus and procedure described by Sharp, Guthrie and Hand (7). The milk entering the apparatus at 105° F. was exposed momentarily to 29 inches vacuum in the deaeration chamber, the temperature dropping to 75° F. Typical results obtained from each of these rapid treating methods involving the use of vacuum are shown in table 9, from which it will be noted that the oxygen remaining in the milk after treatment by either method is practically nil.

TABLE 9

Gas content of milk subjected to vacuum treatment

Method	Vacuum	Oxygen	Nitrogen	Carbon dioxide
	inches	*vol. %*	*vol. %*	*vol. %*
No. 1—Run 1	24.0	0.10	0.40	2.44
No. 1—Run 2	29.0	0.03	0.36	1.70
No. 1—Run 3	29.0	0.01	0.36	1.67
No. 2—Deter. 1	29.2	0.02	0.19	2.01
No. 2—Deter. 2	29.2	0.01	0.19	1.96
No. 2—Deter. 3	29.2	0.06	0.26	2.96

Other methods used for varying the partial pressure of a gas over a solution and consequently effecting removal of gas from solution involve dis-

placement of a particular gas with a different gas. Experimental work embodying this principle consisted in flushing milk with air, nitrogen or carbon dioxide under atmospheric pressure, a positive pressure of 100 pounds and under vacuum. Facilities were readily provided for a comparison of these procedures by an appropriate assembly and manipulation of items of equipment and accessories obtained from the American Instrument Company particularly designed for the handling and control of gas under positive or negative pressures. Typical detailed and summarized data from this series of experiments are shown in the accompanying tables 10 to 13 which show the following relationships: Flushing milk with oxygen at 25 inches vacuum at 11–13° C. for as long as three hours (table 10) causes no reduction in the dissolved oxygen content of milk, as may be expected, but does materially reduce the dissolved nitrogen and carbon dioxide content. Milk flushed with air at 25 inches vacuum at 11° C. for 60 minutes shows a substantial reduction in the oxygen, nitrogen and carbon dioxide content, which with the exception of carbon dioxide, is not substantially reduced upon continued flushing for a two-hour period (table 11). Flushing with air at 25 inches vacuum for 60 minutes at variable temperatures from 11–49° C. causes a reduction in each of the three gases commensurate with the temperature of the milk, the period of treatment and degree of vacuum being constant; the amount of dissolved oxygen remaining after flushing at the highest temperature is practically nil.

Table 12 shows the comparative results obtained by flushing with nitrogen at 100 pounds pressure, at atmospheric pressure, and at 25 inches vacuum at a temperature of 8 to 11° C., from which it will be noted that the dissolved oxygen is reduced to a low value after 40 to 60 minutes. The data also show the anticipated increase in dissolved nitrogen content, saturation or supersaturation with this gas at atmospheric or positive pressure, and the saturation equilibrium at 25 inches vacuum at a consistently lower concentration.

Table 13 shows the results obtained by flushing milk with carbon dioxide at 25 inches vacuum at 13 to 16° C. from which it will be noted that the dissolved oxygen content is reduced to the same low value obtained by flush-

TABLE 10

Gas content of milk flushed with oxygen at 25 inches vacuum
(Temperature—11–13° C.)

Flushing time	Oxygen	Nitrogen	Carbon dioxide
min.	*vol. %*	*vol. %*	*vol. %*
0	0.43	1.25	4.44
90	0.40	0.29	2.82
180	0.38	0.19	1.60
270	0.42	0.34	0.66
360	0.43	0.28	0.49

ing with nitrogen. The dissolved nitrogen content is likewise reduced to a low value whereas, the carbon dioxide content is markedly increased, seemingly to the saturation level of approximately 33 volume per cent.

TABLE 11

Gas content of milk flushed with air at 25 inches vacuum

Flushing time	Temp. of milk	Oxygen	Nitrogen	Carbon dioxide
min.	*°C.*	*vol. %*	*vol. %*	*vol. %*
0	.....	0.48	1.22	5.03
60	11	0.16	0.48	3.79
120	11	0.17	0.45	2.30
0	.....	0.50	1.25	5.40
60	11	0.16	0.47	4.10
0	.....	0.50	1.29	5.11
60	33	0.06	0.30	1.90
0	.....	0.48	1.32	4.94
60	49	0.03	0.24	0.36

TABLE 12

Gas content of milk flushed with nitrogen at atmospheric pressure, 25 inches vacuum and 100 lbs. pressure
(Temperature—8–11° C.)

Flushing time	Atmospheric pressure			25 inches vacuum			100 lbs. pressure		
	O_2	N_2	CO_2	O_2	N_2	CO_2	O_2	N_2	CO_2
min.	*vol. %*	*vol. %*	*vol. %*	*vol. %*	*vol. %*	*vol. %*	*vol. %*	*vol. %*	*vol. %*
0	0.51	1.32	4.13	0.54	1.32	4.14	0.51	1.27	4.43
20	.....	.....	.....	0.18	0.51	3.93	.....	.....	.....
30	0.28	1.63	3.35	.....	.....	.....	.....	.....	.....
40	.....	.....	.....	0.05	0.41	3.32	.....	.....	.....
60	0.05	1.83	2.89	0.05	0.52	2.50	.....	.....	.....
120	0.04	1.72	2.18	0.00	0.42	1.56	0.02	1.87	1.76
150	.....	.....	.....	0.00	0.48	1.07	.....	.....	.....
180	0.04	1.83	1.35	0.01	0.51	0.99	.....	.....	.....
240	0.00	1.80	1.14	0.02	0.61	0.64	.....	.....	.....
300	0.01	1.82	0.64	0.00	0.60	0.39	.....	.....	.....
420	0.01	1.88	0.24	.....	.....	.....	.....	.....	.....

TABLE 13

Gas content of milk flushed with carbon dioxide at 25 inches vacuum—average of four runs
(Temperature—13–16° C.)

Flushing time	Oxygen	Nitrogen	Carbon dioxide
min.	*vol. %*	*vol. %*	*vol. %*
0	0.47	1.26	4.10
90	0.07	0.22	28.20
180	0.03	0.19	31.44

Failure to reduce the carbon dioxide concentration to as low a value as was obtained for oxygen and nitrogen, by flushing with air or nitrogen is in agreement with the general observations of Van Slyke (2) who found it extremely difficult completely to remove carbon dioxide from milk. This gas is reactive and forms ionizable solutions (carbonic acid) in water and also, according to the work of Jackson (3) and Van Slyke (2) previously cited, a portion of the carbon dioxide in milk is presumably bound as bicarbonate, a condition further accentuating difficulty in complete removal by the methods employed. It is to be noted that irrespective of the gas flushing methods used with or without vacuum, the dissolved nitrogen content of the milk was not reduced below 0.19 volume per cent. An explanation for failure to remove this "residual nitrogen" increment cannot be given at the present time, unless the contingent possibilities referred to earlier in this paper inherently prevail in the method of analysis employed.

By applying the mathematical expression of Henry's Law to the data in table 10, assuming little or no absorption of oxygen during collection of the samples, an approximate calculation of the oxygen content of milk in equilibrium with air at atmospheric pressure (approximately 740 millimeters at the authors' laboratory) can be made. This calculated value amounts to 0.54 volume per cent at 12° C. which agrees well with the average value of 0.47 volume per cent oxygen for milk collected at about 15° C. (table 3). If this slight temperature difference is taken into account, it is apparent that the samples of raw mixed milk were saturated with the oxygen to about 87 per cent of the final equilibrium value potentially attainable at this temperature.

The application of Henry's Law for the removal of gases dissolved in milk may be further illustrated with data obtained by pasteurizing milk with the Flowing Film Electric Pasteurizer (9) operated in air and in an atmosphere of nitrogen. The apparatus, including the heating unit and cooler, was inclosed in a manner which permitted a stream of air or nitrogen to be passed over the milk film during heating and cooling in a direction counter to the flow of the milk film. The average results for three complete comparisons at different temperatures are shown in table 14, all samples being taken after cooling. Treatment in air shows no significant reduction in the oxygen content although the nitrogen and carbon dioxide contents are measurably reduced. However, the oxygen content of the samples pasteurized in nitrogen is lowered by approximately 50 per cent which is in agreement with the results obtained from samples of hot milk as previously reported (tables 6 and 7). Substantially little or no oxygen is reabsorbed during cooling in an atmosphere of nitrogen, the oxygen pressure over the milk being nil. The oxygen content of the milk pasteurized at different temperatures is not commensurate with the temperature employed. This may probably be explained by the extremely low and uniform partial pressure of the oxygen at the

surface (at elevated temperatures oxygen is dispelled from the milk into the nitrogen atmosphere at the interface) resulting from the flowing nitrogen, irrespective of the temperature. However, it is recognized that the short time during which the milk is above 145° F., only 0.7 to 0.8 seconds, makes it unlikely that a final equilibrium was reached in all instances.

TABLE 14

Gas content of milk samples pasteurized with flowing film heater in air and nitrogen at various temperatures

(Temperature of samples taken from cooler—52–55° F.)

Pasteurizing temperature	Pasteurized in air			Pasteurized in nitrogen		
	O_2	N_2	CO_2	O_2	N_2	CO_2
°F.	*vol. %*	*vol. %*	*vol. %*	*vol. %*	*vol. %*	*vol. %*
Control	0.35	1.27	4.45	0.35	1.27	4.55
162	0.31	1.06	3.92	0.18	1.16	3.85
172	0.32	1.11	3.84	0.21	1.12	3.66
180	0.32	1.02	3.71	0.16	1.16	3.51
185	0.34	1.13	3.25	0.15	1.19	3.12

Although the amount of oxygen reabsorbed by deoxygenated milk is dependent chiefly on the temperature of the milk and the partial pressure of the oxygen in the contacting atmosphere, the rate of reabsorption is chiefly dependent upon the relative surface exposure per unit of volume. The effect of this factor is well illustrated by the following series of experiments: Milk previously deoxygenated to a uniformly low value by the different methods heretofore described, was exposed to air under integrally controlled conditions by flowing it successively over 1, 2 or 3 eight-inch miniature corrugated coolers contiguously arranged to permit the film to pass from one cooler to another without significant interruption of the continuity of the flow. The deoxygenated milk was introduced in the system at 50° F. and maintained at this temperature during exposure to air, as a flowing film with a capacity of four ounces per inch per minute. The exposure time per unit was substantially two seconds. The results (table 15) show a rapid reabsorption of oxygen during momentary exposure to the atmosphere with a proportionate increase as the time of exposure is increased. The amount of oxygen absorbed does not appear to be influenced by the original nitrogen concentration. This is in agreement with the principle that the solubility of a gas depends on the partial pressure of the same gas over the solution and is independent of the presence of other dissolved gases. Calculation of the oxygen to nitrogen ratios for each of the milks progressively exposed to air under these conditions, shows that the amount of each of the gases going into solution gradually approaches the true solubility ratio of oxygen to nitrogen taken up by water from air. The change in the carbon dioxide values are smaller but are in the proper direction as is to be expected by the low partial pressure of this gas in air and its low initial concentration in the milk used.

TABLE 15

Gas content of deoxygenated and deaerated milk after exposure to air at constant temperature under controlled conditions

Previous treatment	Oxygen vol. per cent aeration time (sec.)				Nitrogen vol. per cent aeration time (sec.)				Carbon dioxide vol. % aeration time (sec.)			
	0	2	4	6	0	2	4	6	0	2	4	6
Vacuum flushed with nitrogen	0.06	0.13	0.21	0.31	1.58	1.58	1.52	1.52	1.59	1.60	1.54	1.44
Vacuum method No. 1	0.02	0.11	0.22	0.27	0.36	0.51	0.64	0.73	1.69	1.63	1.66	1.57
Vacuum method No. 2	0.04	0.15	0.23	0.27	0.81	0.90	0.96	1.03	2.53	2.80	2.45	2.75

It is apparent from the foregoing data that changes in the gas content of milk during various processing procedures are dependent upon the physical laws governing the solution of gases in liquids. It is also shown that substantially all of the oxygen may be removed from milk by subjecting it to vacuum treatment, flushing with other gases, or a combination of these methods. However, if milk of low oxygen content is exposed to air, oxygen is rapidly reabsorbed, the amount being dependent on the temperature and the partial pressure of the gas over the milk; the rate of reabsorption depending upon the extent of the surface exposed. These results are of practical interest in view of the work of Sharp and associates (5, 6, 7) on the relationship between the oxygen content of milk and the destruction of ascorbic acid therein.

THE EFFECT OF LIGHT AND THE OXIDATION OF ASCORBIC ACID ON THE GAS CONTENT OF MILK

The data presented thus far have been concerned primarily with the effect of physical factors of temperature and pressure on the gas content of milk. Another factor which affects the dissolved oxygen content is the oxidation of the ascorbic acid inherently present in milk or that which may be added. Since this oxidation process can readily be traced as a quantative chemical reaction, ascorbic acid may be considered as a chemical reagent for the removal of dissolved oxygen from milk, and conversely the absence of oxygen may be considered as a prerequisite for preventing the destructive oxidation of this factor. Sharp (5), Guthrie (6) and Hand (10) have disclosed the role of oxygen in relation to the ascorbic acid content of milk with particular emphasis on the effects of light, heat, enzymes, and metals as catalysts affecting the rate of oxidation. The primary purpose of the present work is to emphasize the role of ascorbic acid as a deoxygenating agent and to show how this reactive property may be controlled notwithstanding the catalytic effect of light, heat and metals.

In order to facilitate these studies it was first necessary to establish a working procedure whereby the relationship between the quantitative oxidation of ascorbic acid and its rate of oxidation could be correlated with the degree and rate of utilization of the dissolved oxygen. The ascorbic acid determinations were made by the rapid titration method described by Sharp (11). The gas analyses were made by the same methods employed in the previous studies. Since light is known to catalyze the destruction of ascorbic acid in the presence of oxygen, a standardized irradiation procedure was developed which involved exposure of the samples to a "C" carbon arc operated at 50 watts and 60 amps., at a distance of 36 inches. The irradiation was carried out in completely filled cylindrical bottles of flint glass of uniform size and shape rotating at uniform speed on a vertical wheel, thus permitting duplicable exposure conditions from time to time.

The correlation between the destruction of ascorbic acid in milk and the degree of reduction of the dissolved oxygen was determined in two different ways, which may be briefly described as follows: Normal fresh milk was exposed to light under the conditions described above until all the ascorbic acid had been destroyed. (A 30-minute exposure period was found to be sufficient.) The milk was then aerated to assure a normal oxygen content. To this ascorbic acid-free milk there was added approximately 200 mgs. of pure ascorbic acid per liter. Following this addition the ascorbic acid titration value was found to be 195 mgs. per liter and the dissolved oxygen content 0.44 volume per cent. To another sample of normal fresh milk not previously exposed to light to destroy its inherent ascorbic acid content, there was added 100 mgs. of ascorbic acid per liter. Following this addition the ascorbic acid titration showed 114 mgs. per liter and its dissolved oxygen content was 0.53 volume per cent. Each of these samples was then exposed to the standard irradiation treatment for sixty minutes and one hundred eighty minutes, respectively. Table 16 shows the comparative results obtained from each of these samples before and after irradiation, from which it will be noted that the sample containing 195 mgs. ascorbic acid per liter before irradiation had decreased to 146 mgs. at the end of a 60-minute exposure period, showing a loss of 49 mgs. of ascorbic acid. Paralleling this reduction in ascorbic acid, the dissolved oxygen content decreased from 0.44 volume per cent to 0.03 volume per cent. The sample containing 114 mgs. of ascorbic acid per liter prior to irradiation, including the 100 mgs. added and the 14 mgs. inherently present in the milk, showed a reduction to 63 mgs. per liter after a three-hour irradiation period, or a loss of 51 mgs.; the dissolved oxygen content was concurrently reduced from 0.53 volume per cent to 0.01 volume per cent. No measurable difference was found in the nitrogen and carbon dioxide contents of either of the two samples of milk before and after irradiation.

TABLE 16

Gas and ascorbic acid content of milk containing added ascorbic acid before and after irradiation

Sample	Irradiation time	Ascorbic acid	Oxygen	Nitrogen	Carbon dioxide
	min.	*mg./l.*	*vol. %*	*vol. %*	*vol. %*
Raw milk previously irradiated plus added ascorbic acid	0	195	0.44	1.15	2.90
	60	146	0.03	1.23	2.87
Raw milk plus added ascorbic acid	0	114	0.53	1.29	3.59
	180	63	0.01	1.27	3.65

Since the reduction in ascorbic acid content was constant irrespective of the amount present and since the dissolved oxygen content of each sample had been exhausted during irradiation and seemingly within sixty minutes, it may be assumed that the limiting reactive substance was oxygen. Appropriate calculations show that 1.4–1.6 atoms of oxygen disappeared concurrently with the destruction of one molecule of ascorbic acid. Repeated determinations of this value using different milks gave results varying between 1.3 and 1.7 atoms of oxygen per molecule of ascorbic acid with an average value of 1.49 for seven determinations. These results are considered in excellent agreement with the range of values reported by Sharp (12) (1.3 and 1.7) and the average value of 1.4 as reported by Hand (13).

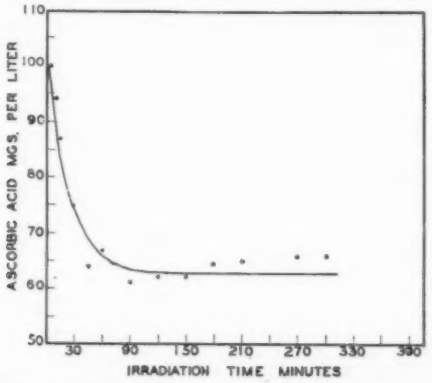

FIG. 2. Rate of destruction of ascorbic acid in milk exposed to intense light.

In view of the fact that further destruction of ascorbic acid could not be brought about by continuing the irradiation period beyond 60 minutes, it was desired to determine the rate of destruction within this period. For this purpose, milk pasteurized in an Electro-Pure apparatus at 195° F. was subsequently aerated to reestablish a normal dissolved oxygen content and 100 mgs. per liter ascorbic acid added. The ascorbic acid titration value follow-

ing this addition showed 105 mgs. per liter. Numerous subsamples of this milk were subjected to the irradiation treatment, individual sample containers being removed from the influence of the light at intervals up to 300 minutes. The ascorbic acid values obtained at the various intervals are shown in table 17 and graphically recorded in figure 2. The sharp initial drop in the curve with subsequent leveling off after approximately 45 minutes clearly show the character and rate of the reaction. The log. of the ascorbic acid concentration as a function of exposure time up to 45 minutes (fig. 3) shows a straight line indicating that destruction of ascorbic acid under these conditions is a first order reaction. This agrees with the work reported by Kon (14) on the destruction of ascorbic acid in raw milk exposed to sunlight.

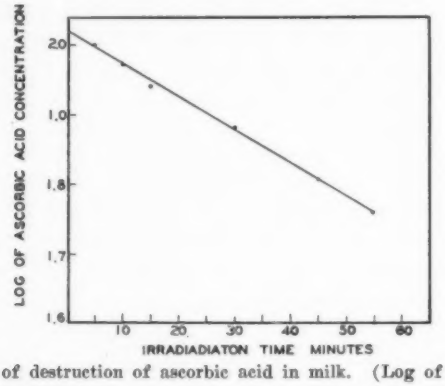

FIG. 3. Rate of destruction of ascorbic acid in milk. (Log of concentration as a function of irradiation time.)

TABLE 17

The rate of destruction of ascorbic acid by light, in milk pasteurized at 195° F.
(Ascorbic acid added = 100 mg. per liter)

Exposure time	Ascorbic acid	Log. ascorbic acid conc.	Velocity constant K
min.	*mg./l.*		
0	105	2.02	.....
5	100	2.00	0.0098
10	94	1.97	0.0111
15	87	1.94	0.0126
30	75	1.88	0.0112
45	64	1.81	0.0110
60	67	.....	.....
90–300	65*	.....	.....

* Average of 9 additional determinations at 30 minute intervals.

The velocity constants (table 17) calculated from the equation for a first order reaction (K = 0.009–0.012) indicate that the reaction rate is only about one-sixth that found by Kon (K = 0.05 to 0.072). This difference may be due

to a difference in the catalytic effect of the light source, possible variation in copper contamination, or to the absence of catalyzing enzymes in the milk pasteurized at 195° F. Undoubtedly the light source is of importance in affecting the velocity of the reaction, as shown by the following summary of data. Velocity constants determined in a similar manner but wherein 100-watt Mazda lamps were used in lieu of the carbon arc, were found to be of a magnitude of K = 0.0015–0.0020, or about one-sixth the values obtained for the more reactive light source, other conditions being the same.

ABSENCE OF DISSOLVED OXYGEN, A PREREQUISITE FOR THE CONSERVATION OF ASCORBIC ACID IN MILK

That the conservation of ascorbic acid in milk is predicated primarily on the absence of dissolved oxygen, may readily be demonstrated by simple but well-controlled experiments. Guthrie, Sharp and Hand (6) have shown such to be the case and further confirmatory data are presented hereinafter. Raw commercial milk having a dissolved oxygen content of 0.51 volume per cent and an ascorbic acid titration value of 15 mgs. per liter, was flushed with air in the absence of light for 90 minutes reducing the oxygen content to 0.20 volume per cent; the ascorbic acid value remained at 15 mgs. per liter. Upon exposure of this milk to the irradiation conditions previously described for 30 minutes, the ascorbic acid was reduced to zero. A parallel sample of mixed raw milk with a dissolved oxygen content of 0.47 volume per cent and an ascorbic acid titration value of 14 mgs. per liter, was flushed in the absence of light for 90 minutes with carbon dioxide, reducing the oxygen content to 0.01 volume per cent, causing no reduction in the ascorbic acid content. This milk with negative oxygen content, upon irradiation for 30 minutes, likewise showed no reduction in its ascorbic acid value. A further sample of fresh raw milk with a normal dissolved oxygen content of substantially 0.47 volume per cent and 14 mgs. ascorbic acid per liter flushed with nitrogen in the absence of light for 90 minutes showed an oxygen content of 0.02 volume per cent and no reduction in ascorbic acid value. The milk thus treated and subsequently irradiated for 30 minutes showed a reduction of only 1 mg. ascorbic acid per liter with no further decrease during an exposure period of 120 minutes. Even the addition of copper, in the amount of 1 mg. per liter as the acetate or lactate, to milk deoxygenated to a low level of 0.02–0.03 volume per cent by one or more of the methods mentioned heretofore, caused a minor reduction of only a few milligrams of ascorbic acid per liter upon exposure for 30 minutes to the intense irradiation employed throughout this work.

Probably a more readily visualized application of the foregoing principles is shown by the following series of experiments designed to determine the degree of conservation of ascorbic acid which would prevail in deoxygenated milk as delivered to and handled by the consumer. Milk of low

oxygen content processed by the deaeration method employed by Sharp and associates and milk of similar low oxygen content obtained by nitrogen flushing methods described herein was run into standard quart milk bottles without particular precautions for preventing exposure to air. The filled bottles were fitted with caps and hoods; one-half of the bottles were stored at ordinary refrigerator temperature for a period of 72 hours, individual bottles being withdrawn at intervals for the determination of dissolved oxygen and ascorbic acid. A parallel group of similarly bottled samples was handled in the same manner but with the exception that subsequent to filling and capping, caps were removed and approximately one-half the milk poured from the bottle. Caps without hoods were replaced and these partially filled bottles with an air column above the milk, were stored under the same conditions as the completely filled bottles; individual bottles being used at intervals for examination. There was no decrease in the ascorbic acid content in the filled, capped and hooded bottles, nor was there any increase in the dissolved oxygen content during a period of 72 hours under ordinary refrigerator storage conditions. These results are to be contrasted with those from the partially filled bottles wherein the dissolved oxygen content of the milk increased from substantially zero to 0.26 volume per cent with a corresponding reduction in ascorbic acid content. Storage periods beyond 24 hours did not cause a significant increase in the dissolved oxygen content, but a decrease in the ascorbic acid progressed constantly to substantially 30 per cent of the original value or the value maintained in the filled, capped and hooded bottles (table 18).

TABLE 18

Oxygen and ascorbic acid content of bottled deoxygenated milk
(Bottling and storage procedure)

Storage condition	Storage time	Oxygen	Ascorbic acid
	hr.	*vol. %*	*mg./l.*
Full bottles capped and hooded	0	0.04	12
	24	0.07	10
	48	0.06	10
	72	0.03	11
Half filled bottles, capped	0	0.04	12
	24	0.26	8
	48	0.25	5
	72	0.25	4

The operability of the physical principles, temperature and pressure, as affecting the gas content of milk and its relation to the stability of ascorbic acid is also shown by another series of experiments which take into account the essential feature of sterilization as prevails in the preparation of commercial evaporated milk. Raw milk and milk pasteurized at 185° F. in the Electro-Pure equipment, then homogenized, was subjected to the following

TABLE 19

Gas and ascorbic acid content of processed milk before and after sterilization

Milk	Before sterilization			After sterilization			After 36 days storage	
	Oxygen	Nitrogen	Carbon dioxide	Oxygen	Nitrogen	Carbon dioxide	Oxygen	Ascorbic acid
	vol. %	*vol. %*	*vol. %*	*vol. %*	*vol. %*	*vol. %*	*vol. %*	*mg./l.*
Raw	0.47	1.63	6.22	0.27	1.51	6.95	0.00	4
" *	0.38	1.37	5.80	0.02	1.76	6.35	0.00	7
" †	0.02	1.35	1.69	0.00	1.72	2.51	0.00	22
Past. and homogenized	0.66	1.56	2.88	0.40	1.66	3.76	0.00	1
" *	0.36	1.68	3.03	0.02	1.94	3.88	0.00	7
" †	0.02	1.60	1.60	0.00	1.82	2.22	0.00	16

* Partially deoxygenated.
† Deoxygenated by vacuum flushing with nitrogen.

treatments: One portion received no further treatment; a second portion was partially deoxygenated; and a third portion was fully deoxygenated by nitrogen flushing methods heretofore described. Each lot was placed in tin cans, hermetically sealed and subjected to the usual sterilization temperatures prevailing in the preparation of evaporated milk. Table 19 shows the significant interrelationship of the dissolved gas content of each of these milks before and after sterilization correlated with the ascorbic acid content following the heat treatment. The undeoxygenated milk has a residual ascorbic acid content, following sterilization and storage, of only one to four milligrams per liter; the partially deoxygenated milk shows an ascorbic acid value of 7 milligrams per liter, whereas the fully deoxygenated but previously pasteurized milk has a value of 16 milligrams per liter and the fully deoxygenated previously unpasteurized and unhomogenized milk has a value of 22 milligrams per liter. It will also be noted that there is a reduction in the dissolved oxygen content during sterilization and subsequent storage and that the degree of reduction seems to follow the decrease in ascorbic acid. Obviously, in those samples where little or no dissolved oxygen was present prior to sterilization, no significant reduction could be detected and in such instances there has been no significant reduction in ascorbic acid.

The particular significance of this series of data is the fact that in the absence of dissolved oxygen, ascorbic acid in milk is stable even at the high temperature necessary for complete sterilization.

SUMMARY

1. The average gas content of mixed raw milk as received at a commercial milk plant over a period of several months was found to be 0.47 volume per cent oxygen, 1.29 volume per cent nitrogen and 4.45 volume per cent carbon dioxide.

2. The effect of temperature and pressure on the gas content of the milk is shown to follow the well-known physical laws governing the solubility of gases in liquids.

3. The oxygen content of hot milk is reduced about 50 per cent at the high temperatures prevailing in short-time pasteurization methods, however, upon subsequent cooling a substantial amount of oxygen is reabsorbed, the degree of reabsorption depending upon the prevailing conditions during cooling; oxygen may be reabsorbed to a higher level than prevailed in the unpasteurized milk if a large surface per unit volume is exposed to air during cooling.

4. Milk may be deoxygenated by subjecting to an appropriate vacuum treatment, flushing with other gases, or a combination of these principles; efficiency of the particular method employed is increased at elevated temperatures.

5. Ascorbic acid may be considered a reactive substance consuming oxygen dissolved in milk. It may be employed as a means of deoxygenating milk and conversely its stability or preservation in milk is dependent upon the absence of dissolved oxygen.

6. In the absence of dissolved oxygen ascorbic acid in milk is stable to intense light for long periods, to the oxidizing effect of copper salts, and to high temperatures in excess of 212° F. as employed for complete sterilization. Light, heat and metallic contamination are considered as catalytic agents which accelerate the oxidation of ascorbic acid in the presence of dissolved oxygen, but are seemingly ineffective in the absence of oxygen.

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THE BACTERIOLOGY OF BRICK CHEESE. I. GROWTH AND ACTIVITY OF STARTER BACTERIA DURING MANUFACTURE[1]

JOHN C. GAREY,[2] EDWIN M. FOSTER,[3] AND WILLIAM C. FRAZIER
Department of Agricultural Bacteriology, University of Wisconsin, Madison

Before 1930 Brick cheese received little attention from research workers, but during the past decade the results of several investigations on methods of manufacture have been published (2, 3, 4, 7, 8, 9, 10, 11, 12, 13, 14, 16), nearly all on the effects of various factors upon the final quality of the cheese, with little information on bacteriological aspects. The purpose of this investigation was to obtain a better understanding of the growth and activity of different bacteria, used alone and in various combinations, in Brick cheese during its manufacture. *Streptococcus lactis* and *Streptococcus thermophilus* were selected, because they are used commonly in the making of Brick cheese.

METHODS

Standard methods were used in the sampling of milk and starters (15). Samples of curd and of curd and whey were collected and prepared according to Frazier and co-workers (5) and Burkey (1). Bacterial counts were made by the direct microscopic method of Frazier *et al.* (5), and by cultural methods to be described.

The cultural medium for counting the starter bacteria had the following composition:

Carrot extract[4]	100 ml.
Liver extract[5]	100 ml.
Difco peptonized milk	10 gm.
Difco Neopeptone	5 gm.
Washed agar	11 gm.
Distilled water	800 ml.

Sodium hydroxide to pH 7.0 ± 0.1

Freshly prepared medium, never over four days old, was used in all experiments. The diluted samples were placed into the tubes of 10 ml. of

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[1] Published with the permission of the director of the Wisconsin Experiment Station.

[2] Now in the Department of Bacteriology, University of Illinois, Urbana.

[3] Now in the Department of Bacteriology, University of Texas, Austin.

[4] Carrot extract: add one liter of water to one pound of ground carrots; heat for one hour in steamer; filter through cheesecloth; bottle and sterilize in autoclave.

[5] Liver extract: add one liter of water to one pound of ground fresh beef liver; heat to 70° C., and hold for thirty minutes; filter through cheesecloth; bottle and sterilize in the autoclave.

melted agar at 45° C. and were mixed thoroughly with the agar. The tubes of solidified agar were incubated for four days in thermostatically controlled water baths. Garey (6) established that it was possible to separate quantitatively *Str. lactis* from *Str. thermophilus* by incubation at 22° C. and at 47° C. The former temperature inhibited the multiplication of *Str. thermophilus* but not of *Str. lactis;* while at the latter temperature the reverse occurred.

The method for the manufacture of Brick cheese was that described by Wilson and Price (16), and by Langhus (11) and will be referred to as the conventional method. Moisture determinations on the cheese were made by the procedure recommended by Wilster *et al.* (17).

The milk was that delivered by one patron of the University of Wisconsin dairy and was of excellent quality; the methylene blue reduction time was never less than seven hours, and the total number of bacteria, determined culturally, always was less than 2,000 per ml. The fat content of the milk ranged between 3.2 and 3.7 per cent. When pasteurized milk was used, pasteurization at 142° F. for 30 minutes was carried out in the cheese vats. Before use, the stainless steel cheese vats, knives, rakes, dipping pails and metal molds were treated with chlorine solution and with scalding hot water.

The starters were prepared in skim milk which had been heated in a steamer for two hours and then cooled to the incubation temperature. *Str. lactis,* a commercial culture, was incubated at 22° C. (72° F.) and the *Str. thermophilus* starter at 37° C. (98° F.).

RESULTS

Streptococcus lactis as the only starter. In the experiments on the manufacture of Brick cheese with 0.6 per cent of *Str. lactis* as the only starter, the growth and activity of the lactic streptococci were studied during the manufacture of the cheese when the curd was cooked to 106° and to 112° F. The milk was pasteurized just before use and then cooled to the setting temperature of 88° or 90° F. The results of a typical experiment in table 1 show that according to cultural counts, *Str. lactis* remained practically constant in numbers until the sixth hour after dipping. However, the direct counts indicated a gradual increase in the numbers of *Str. lactis* and there was a small decrease in the pH of the cheese between dipping and the sixth hour. Between the sixth and twelfth hour after dipping the numbers of *Str. lactis,* as determined by direct or cultural methods, increased rapidly; after the twelfth hour the numbers increased slowly and reached their maximum between the third and sixth day. The pH at one day indicated that the cheese probably would develop a sour flavor. The results also show that a cooking temperature of 112° F., in comparison with 106° F., was harmful to the later growth and activity of *Str. lactis* in the cheese. It will be noted that *Str. thermophilus* never attained appreciable numbers in the cheese.

The data in table 1 reveal the irregularities in counts that are obtained occasionally in a bacteriological study of cheese. Since bacteria in cheese exist in colonies which vary in size and distribution, two samples from a similar location in a cheese may show considerable variation in their bacterial content. In table 1, an example of an irregular count was the excessively high count of *Str. lactis* at the sixth hour in the cheese cooked to 112° F.

Streptococcus thermophilus as the only starter. In the experiments on the manufacture of Brick cheese with *Str. thermophilus* as the only starter, the experimental conditions were the same as described in the preceding section, with the exception that 0.6 per cent *Str. thermophilus* starter was used.

The results of a typical experiment in table 2 show that *Str. thermophilus* multiply rapidly in the vat, and that after dipping the numbers increased steadily until the sixth hour; between the sixth and twelfth hours the numbers increased more slowly and reached their maximum. Cooking to 112° F. favored the growth and activity of *Str. thermophilus* although it had harmed *Str. lactis*. However, the pH at one day was considerably higher with *Str. thermophilus* than with *Str. lactis* and the later development of *Str. lactis* in large numbers with further decrease in the pH of the cheese indicated that the thermophilic streptococcus did not ferment all the sugar in the cheese.

The Brick cheese manufactured from pasteurized milk, wherein either *Str. lactis* or *Str. thermophilus* was the starter and the curd was cooked to 106° or 112° F., showed definite and characteristic defects. The cheese made with *Str. lactis* starter was sour, short and crumbly. That made with *Str. thermophilus* had a very marked fermented or fruity flavor, an excessively open texture, and a weak body. Neither of the starters produced a Brick cheese of satisfactory quality.

With different proportions of Streptococcus lactis and Streptococcus thermophilus starters. In table 3 are shown the results when 0.3 per cent each of *Str. lactis* and *Str. thermophilus* starters were used in the same cheese and two lots of cheese were made, one from raw and the other from pasteurized milk. In table 4 are recorded the results when different proportions of the two starters were used in raw milk; 0.05 per cent of *Str. lactis* and 0.5 per cent of *Str. thermophilus* starters in one lot of cheese, and 0.5 per cent of *Str. lactis* and 0.05 per cent of *Str. thermophilus* starters in the second lot. The cooking temperatures for all the cheese was 106° F.

When equal proportions of the starters were used (table 3), *Str. thermophilus* increased rapidly in numbers in the vat and reached its maximum at the third hour after dipping. At this time, *Str. lactis* was just beginning to multiply; it increased rapidly and reached its maximum numbers at the twelfth hour after dipping. The growth of the starter organisms was slower

TABLE 1

The changes in pH and bacterial content of Brick cheese during manufacture when pasteurized milk and 0.6 per cent Streptococcus lactis starter were used, and the curd was cooked either to 106° F. or 112° F.

Time of sampling	Cooking temperature 106° F.					Cooking temperature 112° F.				
	Millions of bacteria per gram cheese				Acidity	Millions of bacteria per gram cheese				Acidity
	Str. lactis	*Str. thermophilus*	Direct counts			*Str. lactis*	*Str. thermophilus*	Direct counts		
days: hours			*clumps*	*cells*	*pH*			*clumps*	*cells*	*pH*
Milk	0.00025	.....†	.....	.....		0.00025	.....			
Milk + starter	11.5	0.00025	0.13	0.13		9.10	.....	11.0	25.8	
Curd + whey	1.0	0.0002	85.0	147.0		.....	.....	.....	.....	
* 0: 0	15.0	0.0005	93.0	222.0	6.38	12.0	.....	62.0	84.0	6.34
0: 6	15.0	0.20	278.0	460.0	6.12‡	390.0	0.03	710.0	1103.0	6.20‡
0: 12	420.0	0.028	1234.0	1982.0	5.49§	125.0	0.04	542.0	1041.0	5.45§
1: 0	395.0	0.17	500.0	682.0	5.08	195.0	0.21	268.0	461.0	5.07
2: 0	820.0	1.2	.....	.....		430.0	0.17	575.0	926.0	
3: 0	.....	.....	2361.0	3396.0		440.0	0.034	971.0	1487.0	
6: 0	1110.0	0.09	1417.0	2358.0		180.0	0.026	553.0	1019.0	
22: 0	300.0	0.0065	890.0	1257.0		125.0	.....	349.0	494.0	
37: 0	25.0	0.005	272.0	350.0		13.5	0.20	69.0	93.0	

* Zero time taken at dipping.
† . . . indicates absence of colonies in lowest dilutions.
‡ pH at one hour.
§ pH at six hours.

TABLE 2

The changes in pH and bacterial content of Brick cheese during manufacture, when pasteurized milk and 0.6 per cent Streptococcus thermophilus were used, and the curd was cooked either to 106° F. or 112° F.

Time of sampling	Cooking temperture 106° F.					Cooking temperature 112° F.				
	Millions of bacteria per gram cheese				Acidity	Millions of bacteria per gram cheese				Acidity
	Str. lactis	*Str. thermophilus*	Direct counts			*Str. lactis*	*Str. thermophilus*	Direct counts		
days: hours			*clumps*	*cells*	*pH*			*clumps*	*cells*	*pH*
Milk	0.0001	———	0.34	0.41		———				
Milk + starter	———	0.9	0.53	1.5		———	2.7	3.6	9.36	
0: 0	0.002	195.0	647.0	1059.0	6.32	———	240.0	1059.0	1309.0	6.32
0: 6	———*	370.0	2134.0	4435.0	5.64	———*		696.0	1063.0	5.62
0: 12	———*	490.0	2617.0	4421.4		———*	565.0	1493.0	2560.0	
1: 0	0.025	620.0	873.0	1371.0	5.47	———*	660.0	1471.0	2458.0	5.37
2: 0	0.8*	590.0	902.0	1546.0		———*	1000.0	1639.0	2717.0	
3: 0	41.0	465.0	592.0	835.0		———*	660.0	1234.0	2190.0	
6: 0	160.0	425.0	1167.0	1688.0		23.0	240.0	848.0	2044.0	
17: 0	130.0	26.0	1446.0	1870.0		80.0	18.0	1095.0	2508.0	
27: 0	37.0	1.7	1597.0	2095.0		175.0	15.0	1367.0	1916.0	

* Tubes were so badly blown that counting was impossible.

TABLE 3

Changes in pH and bacterial content of Brick cheese during manufacture from raw and pasteurized milk, when Streptococcus lactis and Streptococcus thermophilus starters were used in a 1:1 ratio (0.3 per cent of each)

Time of sampling	Raw milk					Pasteurized milk				
	Millions of bacteria per gram cheese				Acidity	Millions of bacteria per gram cheese				Acidity
	Str. lactis	*Str. thermophilus*	Direct counts			*Str. lactis*	*Str. thermophilus*	Direct counts		
days: hours			*clumps*	*cells*	*pH*			*clumps*	*cells*	*pH*
Milk	0.002	0.0001				0.00005	0.00005			
Milk + starter	2.9	2.2	1.7	3.8		2.20	1.4	3.8	5.9	
0: 0	23.0	39.0	133.0	202.0	6.35	35.5	102.0	178.0	274.0	6.35
0: 3	115.0	675.0	605.0	2340.0	5.37	17.0	580.0	512.0	933.0	5.58
0: 6	215.0	590.0	1207.0	1716.0	5.30	42.0	540.0	644.0	1033.0	5.49
0: 12	475.0	850.0	757.0	1716.0	5.15	130.0	690.0	1034.0	1555.0	5.38
1: 0	340.0	690.0	517.0	708.0	4.97	240.0	795.0	900.0	1565.0	5.25
2: 0	390.0	670.0			5.06	330.0	785.0			4.98
5: 0	200.0	75.0			4.91	170.0	155.0			5.08
10: 0	235.0	80.0			5.03	120.0	135.0			4.99
30: 0	46.5	2.25			5.06	19.0	1.5			5.07

TABLE 4

The changes in pH and bacterial content of Brick cheese during manufacture when raw milk and different ratios of Streptococcus lactis to Streptococcus thermophilus were used and the curd was cooked to 106° F.

Time of sampling	Ratio of *Streptococcus lactis* to *Streptococcus thermophilus*									
	1 (0.05 per cent) : 10 (0.5 per cent)					10 (0.5 per cent) : 1 (0.05 per cent)				
	Millions of bacteria per gram cheese				Acidity	Millions of bacteria per gram cheese				Acidity
	Str. lactis	*Str. thermophilus*	Direct counts			*Str. lactis*	*Str. thermophilus*	Direct counts		
days: hours			*clumps*	*cells*	*pH*			*clumps*	*cells*	*pH*
Milk	0.00017					0.0005				
Milk + starter	0.15	1.3	1.2	4.8		1.6	0.17	0.95	3.5	
0: 0	6.0	72.0	48.0	90.0	6.28	135.0	3.60	61.0	96.0	6.37
0: 3	5.85	205.0	435.0	685.0	5.65	250.0	270.0	623.0	970.0	5.69
0: 6	54.0	270.0	950.0	1645.0	5.57	450.0	265.0	805.0	1392.0	5.31
0: 12	68.0	340.0	760.0	1160.0	5.40	590.0	370.0	827.0	900.0	5.04
1: 0	350.0	500.0	785.0	980.0	5.10	640.0	430.0	463.0	630.0	4.93
3: 0	310.0	96.0			4.97	590.0	350.0			4.97
5: 0	230.0	275.0			5.05	530.0	140.0			4.93
11: 0	110.0	38.0			5.04	245.0	50.0			4.90
30: 0	25.0	0.3			5.00	60.0	0.25			4.97

in the cheese made from the pasteurized milk than in the cheese made from the raw milk. The most rapid drop in pH was during the first three hours after dipping, when *Str. thermophilus* was most active.

Table 4 shows that, regardless of the initial numbers of *Str. thermophilus*, its growth and activity practically ceased by the third hour after dipping. When the initial numbers of *Str. lactis* were high, growth and changes in acidity were more rapid than when the original numbers were low. Because the cheese manufactured with the larger amount of *Str. lactis* contained more moisture and hence more lactose, the final pH was lower than in the cheese made with the smaller amount of the lactic starter.

The quality of the cured cheese was recorded in accordance with the proposed system of Hanson (7), as modified by Langhus (11); that is, the flavor, texture, body and color were scored on a basis of 1 as perfect and 6 as unsalable. A perfect total score would be 4. The results in table 5 show that the cheese made from the pasteurized milk and equal parts of the starters and the cheese made from raw milk and the larger amount of *Str. thermophilus* and smaller amount of *Str. lactis* starters was of better quality than the other two lots of cheese, one of which was manufactured from raw milk and equal parts of the starters, and the other from raw milk and the smaller amount of *Str. thermophilus* and larger amount of *Str. lactis* starters. This fact demonstrated that there was a very delicate balance between the moisture content of the cheese and certain defects. A moisture content of more than 42 per cent after salting was a practical guarantee of a cheese with the defects in flavor and body characteristic of an acid cheese.

TABLE 5

A comparison of the effect of different proportions of Streptococcus lactis and Streptococcus thermophilus upon the moisture, acidity, and quality of Brick cheese

Ratio of *Str. lactis* to *Str. thermophilus*	After salting		After curing*				
			Score†				
	Moisture	Acidity	Flavor	Body	Texture	Color	Total
	per cent	*pH*					
1: 1 (raw milk)	44.8	4.91	3.3	3.1	3.0	1.9	11.3
1: 1 (past. milk)	42.6	5.04	2.8	2.8	2.6	1.0	9.2
1: 10 (raw milk)	42.4	5.00	2.8	2.5	2.8	1.0	9.1
10: 1 (raw milk)	45.5	4.90	3.5	3.0	2.3	3.0	11.8

* Ages of the cheese varied from five to eight weeks.

† Scored according to system of Hanson (7) and Langhus (11), in which a value of 1 is perfect and 6 means unsalable.

DISCUSSION

When the conventional method of manufacture of Brick cheese was used and *Str. lactis* was the only starter, the cheese developed a sour flavor and

crumbly body unless special care was taken to limit the moisture at dipping. In order to produce a Brick cheese with a sweet flavor and a smooth body under the above manufacturing conditions, it was necessary to increase the length of the cooking period, and thereby decrease the moisture in the curd at dipping. Another method of controlling the moisture in the curd was to raise the cooking temperature, but it could not be increased above 106° F. or the later development of the *Str. lactis* organisms would be retarded. It was necessary to control the moisture before dipping, because during most of the draining the growth and activity of the lactic streptococci were not very extensive and their effect upon the amount of draining was negligible. Therefore, if the curd was not relatively dry at dipping, the moisture of the cheese remained high and the defects of an acid cheese developed.

When *Str. thermophilus* starter was used alone under the above manufacturing conditions, usually the cheese developed an undesirable fermented or fruity flavor and a very open texture. At the third or fourth hour after dipping, the growth and activity of the thermophilic streptococcus practically stopped, because of the unfavorably low temperature in the cheese. At that time, considerable amounts of lactose remained in the cheese and the pH was relatively high, and therefore conditions were favorable for the growth of other bacteria. Under the conditions of this investigation, the other bacteria were apparently the kinds which could ferment the lactose and lactates with the production of volatile compounds which were responsible for the fermented or fruity flavor and the gassy or open texture of the cheese.

When the proper proportions of *Str. lactis* and *Str. thermophilus* were used under the above manufacturing conditions, the defects which resulted from the use of either of the above starters alone were eliminated, and a Brick cheese of acceptable quality was produced. The reason that a combination of starters was better than either alone was that the *Str. thermophilus* organisms multiplied rapidly in the vat and during the first three hours after dipping. During this time, therefore, there was a steady production of acid and the draining was more extensive than when the thermophilic streptococcus was absent. It was pointed out in a previous statement that when *Str. thermophilus* was the only starter there would be certain defects which resulted from an incomplete fermentation of the sugar and the consequent growth of undesirable bacteria. However, in a combination of the starters, the *Str. lactis* organisms started to grow at the third hour after dipping and completed the fermentation which had been initiated by the *Str. thermophilus* bacteria. However, if the *Str. lactis* starter was used alone, the draining was more than half completed before the growth of the *Str. lactis* organisms became rapid, and the cheese retained a relatively high amount of moisture and became an acid product with characteristic defects.

The results of this investigation have indicated that in order to produce

a Brick cheese of acceptable quality by the conventional method of manufacture it was necessary to decrease the moisture of the cheese well below the legal limit of 43 per cent, otherwise a cheese with a sour flavor and a weak or crumbly body developed. A lower moisture would result in a corresponding loss in yield and hence in profit. Any method which would permit the retention of moisture up to the legal limit without harm to the quality of the product should be very desirable to the manufacturers of Brick cheese.

SUMMARY

A study was made of some of the bacteriological, chemical and physical changes in Brick cheese during its manufacture. The following results were obtained:

1. When Brick cheese was manufactured by the conventional method from raw or pasteurized milk:

a. With *Str. lactis* as the only starter special care was required in the control of the moisture at dipping, otherwise a sour flavor and a weak or crumbly body developed. If the moisture content at two days was higher than 42 per cent, the above defects developed in the cheese.

b. With *Str. thermophilus* as the only starter a fermented flavor and open texture developed in the cheese.

c. With a combination of the above two starters, a better quality of cheese was produced than when either was used alone.

2. During the manufacture of Brick cheese, the growth and activity of the starter bacteria were as follows:

a. *Str. thermophilus* practically stopped growth at the third or fourth hour after dipping because of the relatively low temperature in the cheese.

b. The growth and activity of *Str. lactis* were not very extensive until the latter part of the draining period. It usually reached its maximum numbers within one or two days. When the original inoculum was large (0.5 per cent or more) growth and activity were more extensive during the early part of the draining period.

3. The cooking temperature could not be raised above 106° F. without greatly retarding the growth and activity of *Str. lactis*. However, a cooking temperature of 112° F. increased the rate of growth and activity of *Str. thermophilus*.

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THE EFFECT OF HYDROGENATION ON THE NUTRITIVE VALUE OF THE FATTY ACID FRACTIONS OF BUTTER FAT AND OF CERTAIN VEGETABLE OILS*

R. K. BOUTWELL, R. P. GEYER, C. A. ELVEHJEM AND E. B. HART
Department of Biochemistry, University of Wisconsin, Madison, Wisconsin

Studies on the comparative nutritive value of butter fat and certain vegetable oils (1) showed that butter fat homogenized into raw skimmed milk with ample fat soluble vitamins and minerals added and fed *ad libitum* to weanling rats gave better growth than did corn oil, coconut oil, cottonseed oil, and soybean oil fed in a like manner. Further study disclosed that the factor (or factors) responsible for the superior growth of rats on butter fat milk did not lie in the non-saponifiable fraction of butter fat (1), nor did such compounds as egg lecithin, sphingomyelin, sphingosin, or ethanol amine have any effect on the nutritive value of the vegetable oils used in our experiments. Choline was also tried and showed slight growth promoting effects on the females (2). Later experiments (unpublished) have shown that the addition of choline (30 mg. per day) has had no growth promoting effect when added to butterfat or any of the vegetable oils fed in skimmed milk. The separation of the fatty acids of butter fat into a volatile fraction by steam distillation and into a saturated and an unsaturted fraction by lead soap solubilities in alcohol was carried out. Feeding the glycerol esters of each of these fractions in corn oil indicated that the factor responsible for the superior growth with butter fat milks lay in the saturated fraction of butter fat (3).

To gain further insight as to the nature of the substance responsible for the better growth promoting value of butter fat milk, complete catalytic hydrogenation of the saturated fraction was necessary to eliminate the possibility that an unsaturated compound insoluble as the lead soap or carried along with the insoluble lead soaps was the active principle of the saturated fraction. The iodine numbers of various preparations of the saturated fraction varied from 6 to 10. The effect of hydrogenation on the nutritive value of the unsaturated fraction was also determined in the present study. In view of the increased growth obtained on the hydrogenated butter fat fractions, feeding experiments were also carried out on various hydrogenated vegetable oils. The results of this experiment are included in this paper.

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EXPERIMENTAL

The fatty acid fractions of butter fat were prepared essentially by the method of Hilditch (4) and as previously reported by us (3). The steam volatile fraction was discarded. The triglycerides of the saturated and the unsaturated fractions were prepared by heating theoretical amounts of the fatty acid fractions and glycerol together at 200° C. in a three-neck round-bottom flask for 6 hours with an efficient mercury seal stirrer and in an atmosphere of carbon dioxide (5). Both the saturated and unsaturated glycerides were completely hydrogenated over Raney nickle at 150° C. and 1600 to 2200 pounds pressure without a solvent.[1]

All feeding trials were carried out in the usual manner (1, 2, 3). Weanling rats about 20 days old were used throughout. Three males and three females in individual cages were placed in each group. The fats were homogenized into fresh raw skimmed milk at a 4 per cent level with a laboratory homogenizer. Ten micrograms of carotene were dissolved in each gram of butter fat and 20 micrograms of carotene were added to each gram of the other fats. All rats were irradiated 10 minutes each day and 100 micrograms of α-tocopherol acetate were given to each rat every week. The milk was mineralized so that every 100 cc. contained 1.5 mg. of iron and 0.15 mg. each of copper and manganese. The milks were fed *ad libitum* and consumption records kept, care being taken to feed each rat only a small excess over the amount that it could consume in one feeding.

Six groups of rats—three males and three females in each group for each experiment—were set up and fed as follows for 6 weeks:

Group I—Butter fat
" II—Corn oil
" III—Corn oil plus saturated fraction butter fat
" IV—Corn oil plus hydrogenated saturated fraction butter fat
" V—Corn oil plus unsaturated fraction butter fat
" VI—Corn oil plus hydrogenated unsaturated fraction butter fat

The glycerides of each fraction were mixed in *equal proportions* with corn oil (Mazola) each day just before homogenization into the skimmed milk. As above stated the total fat content of the milk was 4 per cent. Three such experiments were carried out.

Growth of the rats on the hydrogenated butter fat fractions in grams during the first three weeks of the experiment is tabulated in table 1. The average grams gained as shown in the last line, representing 9 males and 9 females in each group (except groups III and V where 6 males and 6 females are represented) are graphed in figure 1. The animals on corn oil plus the saturated fraction of butter fat grew slightly faster than animals on butter fat and considerably faster than animals on corn oil, while the

[1] We wish to thank Dr. Homer Adkins of the University of Wisconsin Chemistry Department for the hydrogenation of the fats.

TABLE 1

Growth on the hydrogenated fatty acid fractions

The figures show grams gain made during the first three weeks on the experiment. Each figure represents the average of three rats.

Diet	Butter fat		Corn oil		Corn oil plus sat. fract.		Corn oil plus hyd. sat. fract.		Corn oil plus unsat. fract.		Corn oil plus hyd. unsat. fract.	
Sex	M	F	M	F	M	F	M	F	M	F	M	F
Expt. 22	70	62	67	58	80	69	69	73	63	63	81	75
Expt. 24	87	71	64	57	—	—	72	68	—	—	88	70
Expt. 29	72	67	60	60	80	69	76	71	73	53	90	71
Average	76	67	64	58	80	69	72	71	68	58	86	72

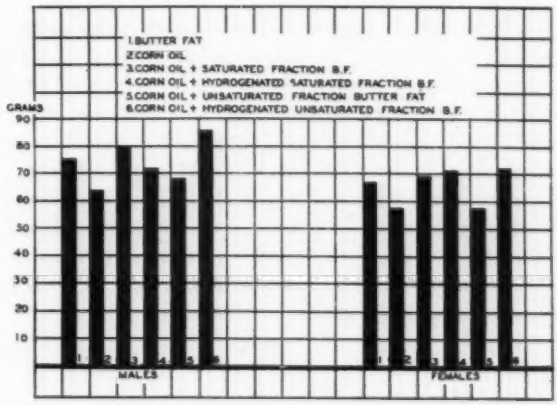

FIG. 1. Average gains made during the first three weeks on experiment by male and female rats representing 18 rats (9 males and 9 females) for each bar, except bars 3 and 5 where 6 males and 6 females are represented.

animals on corn oil plus the unsaturated fraction grew at about the same rate as those on corn oil. This confirms our earlier findings (3). Rats fed the hydrogenated saturated fraction grew at about the same rate in the case of the females and somewhat slower in the case of the males than those on the saturated fraction. Rats on corn oil plus the hydrogenated unsaturated fraction grew much better than those of any other group. The fur coat of the rats on the saturated and hydrogenated butter fat fractions was superior to that of the rats on corn oil.

In table 2 are recorded the cc. of milk consumed for each gram of gain in weight. In the case of the butter fat only and the various butter fat fractions, the amounts of milk ingested are quite constant. Somewhat higher amounts of skimmed milk, reinforced with corn oil only, were re-

TABLE 2

Number of cc. of milk required to produce one gram gain in weight over the first three weeks on experiment

Diet	Butter fat		Corn oil		Corn oil plus sat. fract.		Corn oil plus hyd. sat. fract.		Corn oil plus unsat. fract.		Corn oil plus hyd. unsat. fract.	
Sex	M	F	M	F	M	F	M	F	M	F	M	F
Expt. 22	12.2	13.1	13.5	13.8	13.5	13.6	13.3	14.4	13.3	13.5	13.0	14.3
Expt. 24	13.1	13.6	14.3	16.1	—	—	12.8	13.4	—	—	11.2	13.8
Expt. 29	11.8	13.1	13.0	13.2	11.7	13.5	12.2	13.4	11.2	14.7	11.7	12.9
Average	12.3	13.3	13.6	14.4	12.6	13.6	12.8	13.7	12.3	14.1	12.0	13.3

quired for each gram of gain, although the differences may not be especially significant.

For study of the effect of hydrogenation on their nutritive properties, corn oil, coconut oil, cottonseed oil, and soybean oil were completely hydrogenated over Raney nickle. These oils were refined products, with the exception of soybean oil, which was crude. The hydrogenated corn oil, hydrogenated cottonseed oil, and hydrogenated soybean oil were each mixed 1 part to 3 parts of the same oil not hydrogenated. The hydrogenated coconut oil was mixed in equal proportions with unhydrogenated coconut oil. A commercial, partially hydrogenated cottonseed oil (a shortening) was also fed in this experiment. Ten groups were set up, each group consisting of three males and three females. They were fed skimmed milk in the usual manner, with mineral and fat soluble vitamin fortification.

Group	*Component fats*	*Per cent of total fat*	*Total fat per cent*
1	Butter fat	100	4
2	Corn oil	100	4
3	Hydrogenated corn oil	33	4
	Corn oil	66	
4	Coconut oil	100	4
5	Hydrogenated coconut oil	50	4
	Coconut oil	50	
6	Cottonseed oil	100	4
7	Hydrogenated cottonseed oil	33	4
	Cottonseed oil	66	
8	Soybean oil	100	4
9	Hydrogenated soybean oil	33	4
	Soybean oil	66	
10	Crisco	100	4

Table 3 shows the average gains in grams of the males and females in each group at the end of 3 weeks and at the end of 6 weeks. The gains at the end of 3 weeks are graphed in figure 2. In all cases hydrogenation of the vege-

TABLE 3

Growth on the hydrogenated vegetable oils showing average grms gained during the first three weeks and total grams gained (each figure represents three rats)

Diet	Butter fat		Corn oil		Corn oil plus hyd. corn oil		Coconut oil		Coconut oil plus hyd. coconut oil		Cotton-seed oil		Cottonseed oil plus hyd. cotton-seed oil		Soybean oil		Soybean oil plus hyd. soybean oil		Crisco	
Sex	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
At 3 wks. (grams)	73	64	62	57	57	53	47	47	42	42	72	59	50	55	73	61	51	53	62	53
At 6 wks. (grams)	141	128	131	111	119	98	88	90	107	89	157	113	110	107	159	113	107	98	131	106

TABLE 4

Growth on the hydrogenated vegetable oils showing number of cc. of milk required to produce one gram gain in weight over the first three weeks on experiment (6 animals on each fat—3 males, 3 females)

Diet	Butter fat		Corn oil		Corn oil plus hyd. corn oil		Coconut oil		Coconut oil plus hyd. coconut oil		Cotton-seed oil		Cottonseed oil plus hyd. cotton-seed oil		Soybean oil		Soybean oil plus hyd. soybean oil		Crisco	
Sex	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
cc.	11.9	14.0	12.7	14.1	13.8	15.4	14.4	16.8	16.0	17.4	12.1	13.9	14.1	14.6	12.5	13.7	15.4	16.8	12.8	15.8

table oils did not improve their growth promoting properties. These results show that certain male rats on cottonseed oil and soybean oil gained about the same amount in the first 3 weeks as those on butter fat and at the end of 6 weeks had gained somewhat more than the males on butter fat. The partially hydrogenated cottonseed oil gave about the same growth as corn oil and was slightly better than the hydrogenated cottonseed oil—cottonseed oil mixture in the case of the males. In an earlier trial corn oil was mixed in equal parts with completely hydrogenated corn oil and fed with results similar to those secured in this experiment.

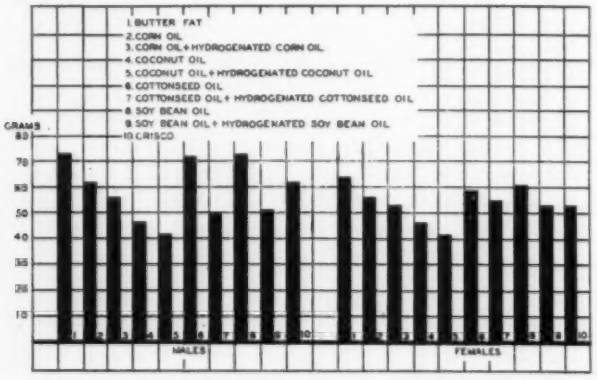

FIG. 2. Average gains made during the first three weeks on experiment of male and female rats representing 6 rats (3 males and 3 females) for each bar.

Records of milk consumption per gram of weight increase are recorded in table 4. The butter fat fed rats show a slightly lower milk consumption per gram of growth, particularly the males. In the case of the females there was a slightly greater efficiency in the case of cottonseed oil and soybean oil than with butter fat. In any case the differences are too small to be of significance. As already stated, earlier published data as well as unpublished data show generally that butter fat is superior to cottonseed oil and soybean oil in *ad libitum* feeding with skimmed milk as the basal diet. An *occasional* rat, through synthetic ability or storage will grow quite as well on some of the vegetable oils as on butter fat, thereby giving an average result contrary to the general findings.

DISCUSSION

The results obtained on the hydrogenated butter fat fractions indicate that the superiority of butter fat lies in the saturated fraction. The unsaturated fraction added to corn oil gave no response in growth over corn oil alone, indicating that the superior growth-promoting property of butter fat is probably not due to an unsaturated fatty acid. Since either fraction com-

pletely hydrogenated gave growth as good or better than butter fat itself, it is probable that a long chain saturated fatty acid (or acids) is responsible for the superior growth-promoting value of butter fat. It is evident that the unsaturated fraction of butter fat contains an unsaturated form of the compound which may readily be converted to the active form by catalytic hydrogenation. The better growth obtained with certain fractions over the butter fat alone might well be explained by the fact that in the mixtures of these fractions with corn oil there was more of the high molecular weight saturated fatty acid (or acids) present than in butter fat alone.

The unsaturated form of the growth-promoting saturated fatty acid is apparently not present in the vegetable oils studied. The poorer growth found on feeding hydrogenated vegetable oils may be a factor of digestibility, since the hydrogenated vegetable oils had high melting points. This possibility was not studied. Individual male rats on cottonseed oil and soybean oil showed somewhat better growth than the control rats on butter fat in this experiment. This was the only experiment in which this occurred and was an individual performance. Earlier experiments (1) and more recently secured data (unpublished) on cottonseed oil and soybean oil show that these oils are inferior to butter fat in growth promoting value.

In this investigation, as well as those previously recorded on the same subject, we have used the "*ad libitum*" method of feeding rather than the "paired feeding" method. We have done this because we believe that the "*ad libitum*" method does not penalize the more efficient ration and serves to emphasize any distinctive nutritive differences. The critics of *ad libitum* feeding for these types of experiments maintain that differences in growth are due to increased appetite, greater palatability and greater consumption, rather than to some needed nutrient. Of course, this is exactly the result of a superior food over an inferior food. A favorable physiological response engendered by the superior food results in a greater consumption and better growth.

Since in these experiments the only variable was the fat or fat fractions, then a fat or oil giving better results in growth than another fat or oil must accomplish this through its effect on the animal's physiology. Hardly could one expect a fat fraction, after the chemical manipulation to which it has been subjected, to improve the appetite as compared with the raw corn oil. The consumption records support no such view. Corn oil invariably induced inferior growth to that obtained with butter fat or butter fat fractions and the daily consumption was also less.

We are convinced that the *ad libitum* feeding method in this type of experimentation will more clearly express any difference in the nutritive value of the fats or oils under investigation than a method that limits consumption. We think we are correct when we say that no new dietary factor has ever been disclosed by the use of the "paired feeding" method. A con-

trol animal limited in its intake to the amount of food consumed by an animal suffering from a deficiency must sooner or later have its consumption reduced to zero. Ultimately that is exactly the consumption level reached by an animal fed a deficient ration. Only short-time records will obliterate such a condition unless internal synthesis wholly or partially intervenes.

CONCLUSIONS

1. The superior growth-promoting property of butter fat as compared to certain vegetable oils is probably due to a saturated compound; apparently a long chain saturated fatty acid (or acids) present in small amounts in butter fat is responsible for these properties of butter fat.

2. The unsaturated fraction of butter fat is relatively rich in an unsaturated form of this compound which by hydrogenation may readily be converted to the active compound.

3. Certain vegetable oils as corn oil, coconut oil, cottonseed oil and soybean oil apparently do not contain the unsaturated form of this compound. Hydrogenation of these vegetable oils did not improve their nutritive value when incorporated into skimmed milk.

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OXIDIZED FLAVOR IN MILK. X. THE EFFECT OF FEEDING POTASSIUM IODIDE SUPPLEMENTS TO DAIRY COWS ON THE CAROTENE CONTENT OF THE BUTTER FAT AND ON THE ASCORBIC ACID CONTENT OF THE MILK AND THE RELATIONSHIP TO METAL-INDUCED OXIDIZED FLAVOR*

W. CARSON BROWN,[1] A. H. VANLANDINGHAM,[2] AND CHAS. E. WEAKLEY, JR.[2]
West Virginia Agricultural Experiment Station, Morgantown

It has been found that the level of the iodine content in milk follows the same seasonal variation as the susceptibility of milk to oxidized flavor. Likewise, the carotene content of the butter fat follows this same seasonal trend. Koch (6) first reported changes in the iodine content of the thyroid gland with the changing seasons. Later, Seidell and Fenger (15) and Fenger (4) made studies of the iodine content of the thyroids of cattle, hogs, and sheep, special attention being paid to seasonal variations. It was found that there were two or three times as much iodine present in the thyroid in the months between June and November as in the months between December and May. Kendall and Simonsen (5) likewise found seasonal variation in the thyroid of swine. Mathews, Curtis, and Meyer (8) found that during the late spring the milk iodine from both normal and iodine-supplemented cows was unusually low. The milk from the cows receiving iodine contained from 7 to 26 times as much iodine as that from the control cows. Ralston and co-workers (13) reported that the fact is well established that iodine is a normal constituent of the thyroid gland and that iodine must be supplied to an animal for normal activity of the gland which in turn reflects its importance on metabolic activity.

Treichler *et al.* (17) and Fashold and Heideman (3) found that goat butter contained vitamin A but very little carotene. The latter reported that after thyroidectomy, vitamin A *per se* is absent and large amounts of carotene are present.

Since the level of the iodine in the milk follows the same seasonal change as the susceptibility of milk to oxidized flavor, and since it has been demonstrated in the case of the goat that the thyroid affects the ratio of vitamin A to carotene in the milk, it seemed possible that iodine through its effect on the thyroid might bring about a change in the susceptibility of milk to mental-induced oxidized flavor. Accordingly the following experiment was planned and conducted.

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[1] Department of Dairy Husbandry.

[2] Department of Agricultural Chemistry.

EXPERIMENTAL

Five Jersey cows, whose milks were susceptible to oxidized flavor when contaminated with copper, were selected from the regular milking herd. In addition to the regular herd ration, each cow was given a supplement of 5 grams of potassium iodide daily for a period of 14 days. All other factors were maintained as nearly uniform as was possible.

Three quarts of milk were collected from each cow at the morning milking on the first three consecutive days of each week and carotene, ascorbic acid, and flavor determinations were made. The ascorbic acid was determined on the individual samples of raw milk, as soon as possible after milking, by titrating as suggested by Sharp (16). The remaining milk was pasteurized in bottles. Following pasteurization and cooling, four one-half

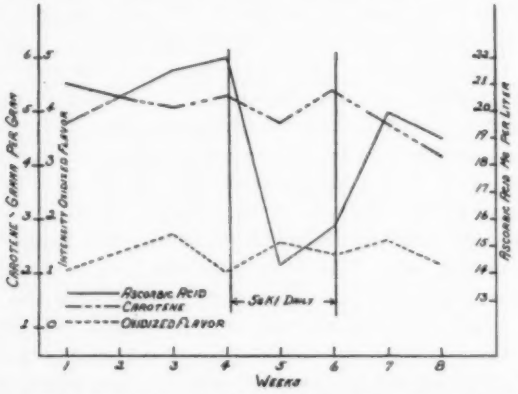

FIG. 1. The effect of potassium iodide supplements on the carotene content of the butter fat and the ascorbic acid content of the milk and the relationship to metal-induced oxidized flavor.

pint samples were prepared containing none, 0.5, 1.0, and 1.5 parts per million, respectively, of copper from a copper sulphate solution. These samples were then stored in ice water for three days, after which they were scored for flavor by at least three judges familiar with oxidized flavor. The remainder of the milk was prepared for carotene analysis by gravity separation of the cream followed by churning. Before churning, the cream from each of the three days was composited so as to make one churning and one analysis for carotene per cow per week. The butter thus obtained was melted and centrifugalized in Hart's casein tubes in an electrically heated centrifuge for 15 minutes, after which the clear, liquid butter oil was decanted into a clean, dry jar. The carotene analyses were made according to the method of Baumann and Steenbock (1) modified by Rogers and associates (14). After a four-week preliminary period on normal herd ration, each of the cows was given a daily supplement of 5 grams of

potassium iodide. The potassium iodide was administered by drenching so that the cows received the full amount of the dosage. The supplement was given for 14 days. Three of the cows upon finishing the potassium iodide feeding period and a two-week readjustment period were dropped from the experiment. Following a seven-day readjustment period the remaining two animals were given another 14-day potassium iodide feeding period. At the end of this period the experiment was discontinued. The dosage during the second feeding period was likewise 5 grams daily.

The results of this study are shown in figures 1 and 2. Figure 1 shows the results obtained with the three cows which received the supplement for only one period. These results show that there was a decided decrease in the amount of ascorbic acid secreted in the milk. As soon as the supplement was discontinued the ascorbic acid rose very sharply to approximately normal. The carotene content of the butter fat and the intensity of the metal-induced oxidized flavor remained fairly constant throughout the experiment.

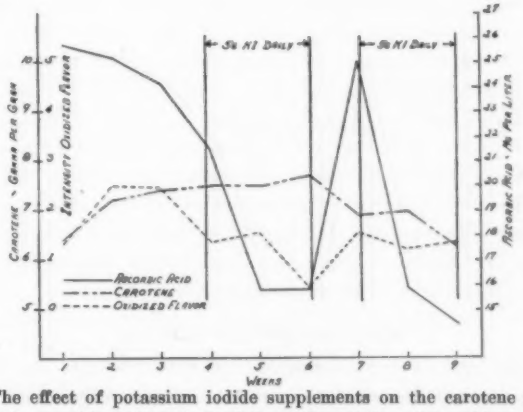

FIG. 2. The effect of potassium iodide supplements on the carotene content of the butter fat and the ascorbic acid content of the milk and the relationship to metal-induced oxidized flavor.

Figure 2 shows the same general type of results as figure 1 except that the ascorbic acid content was lowered a second time by the feeding of potassium iodide. This shows clearly that the reduction in ascorbic acid in the first three animals was not coincidental. Here also no effect was noted in the level of the carotene or in the intensity of the oxidized flavor.

DISCUSSION

The feeding of 5 grams daily of potassium iodide was sufficient to reduce the ascorbic acid content of the milk approximately one-third. The potassium iodide supplement, however, did not affect the carotene content of the butter fat or the intensity of metal-induced oxidized flavor. This

indicates that the ascorbic acid content of the milk may not be an important factor in the development of oxidized flavor and supports recent information as reported by the authors (2).

There may be a very different and indirect application of these results. Phillips and Stare (12) found a high concentration of ascorbic acid in the pituitary gland of cattle and later Phillips and co-workers (11) reported a low blood plasma ascorbic acid content in cattle fed on restricted dietary regimes. Likewise, it was shown by Lardy and Phillips (7) that fresh semen from bulls with low fertility had less than 2 mg. of ascorbic acid per 100 cc., and in some cases only a trace was found. Good breeding bulls, on the other hand, produced semen containing 3.0–8.0 mg. of ascorbic acid per 100 cc. of fresh semen. In a later work Phillips *et al.* (10) showed that the subcutaneous injection of ascorbic acid results in the restoration of the fertility of certain bulls. During the past year these workers (9) have shown that ascorbic acid is intimately associated with the early phases of the reproductive processes and that it can be successfully used as a therapeutic measure in treating certain types of sterility in the cow. From these findings it seems possible that heavy iodine feeding might affect the ascorbic acid level of the blood and thus influence breeding efficiency. It is a common belief among some veterinarians and animal breeders that heavy iodine feeding rendered cows sterile for a period following such treatment, but a review of the literature thus far has failed to reveal experimental evidence on this point. In view of the effect of potassium iodide on the ascorbic acid content of the milk it seems entirely possible that potassium iodide might lower breeding efficiency by affecting the ascorbic acid content of the blood. However, further experimental proof is needed to substantiate or disprove the effect of potassium iodide on the efficiency of breeding.

SUMMARY AND CONCLUSIONS

1. The feeding of 5 grams daily of potassium iodide for fourteen days lowered to a marked degree the percentage of ascorbic acid secreted in the milk, but had no noticeable effect on the level of the carotene content of the milk.

2. The decrease in the ascorbic acid content of the milk did not produce a corresponding increase in the intensity of the metal-induced oxidized flavor.

3. From these results it appears that the level of the ascorbic acid in the milk may not be as great a factor in the production of milk with low susceptibility to oxidized flavor as was formerly believed.

ACKNOWLEDGMENT

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AN ANALYSIS OF THE RELATIONSHIP BETWEEN THE CURD TENSION AND THE CURD SURFACE AREA OF MILK

ARNOLD B. STORRS

American Seal-Kap Corporation, Long Island City, N. Y.

For the past several years there has been a growing interest within the dairy industry in the commercial preparation of so-called modified milk, or fluid milk with improved digestibility. This has naturally led to a more intensive study on the part of research workers of the factors related to digestibility. Many attempts have been made to develop new and possibly more accurate *in vitro* tests which would simplify control problems. The curd tension test, originally proposed by Hill (1) and subsequently modified by others (2, 3), is still the only generally accepted test of this nature and its wide use has, in fact, led to the general designation of such modified milks as "soft curd milk."

In several of the techniques which have been proposed recently (4, 5, 6, 7, 8) the property of curd particle size or curd surface area has had an important bearing upon the estimation of comparative digestibility. These studies have led many to agree with the viewpoint expressed by Doan (9), that the size of the curd particles obtained in peptic coagulation under conditions of agitation and acidity closely approximating those existing in the stomachs of young infants would be a more suitable index of digestibility than the toughness of the curd formed without any agitation.

Since the curd tension test and the newer methods which have been suggested are all intended as *in vitro* measures of digestibility, the question of correlation between the results obtained by different procedures naturally arises. Chambers and Wolman (6) reported some agreement between curd tension and curd surface area. Their conclusions were based upon a comparison of different types of milk and the determinations of curd surface area were made at pH levels of about 4.5 to 5.0 only. They also observed that there were some apparent exceptions.

It was the purpose of this investigation to make a statistical analysis of the relationship between curd tension and curd surface area as it exists both within individual types of milk and within groups of mixed samples of different milks.

EXPERIMENTAL

Source of samples: Several types of milk were tested, including untreated milk, homogenized milk (high pressure), enzyme-treated milk (pancreatic enzyme) and base exchange milk. All of the milk analyzed was purchased from milk plants that were making or selling the particular type of modified milk.

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Curd tension: The technique tentatively recommended by the Curd Tension Committee of the American Dairy Science Association (10) was followed. A Submarine Signal curdometer was employed for making the readings and a thermostatically controlled water bath maintained at 95 ± 1° F. was used for tempering the reagents and the samples and for incubating the test samples.

Curd surface area: Curd surface area was determined by the Chambers-Wolman test (5, 6) using the modified technique described by Anderson (8). Briefly, 100 ml. of milk was coagulated in thin-walled latex sacs by the addition of sufficient pepsin-hydrochloric acid coagulant (equal parts of a 0.6 per cent aqueous solution of pepsin, U.S.P. 1:3000, and Normal HCl) to give the desired pH. After a "digestion" period of thirty minutes with constant mechanical agitation the samples were emptied into individual containers and hardened with formaldehyde. Curd surface area values were calculated after washing the curds through a series of graduated sieves and weighing the various amounts of each size fraction. Determinations were made at pH levels of 6.0, 5.5, 5.0, 4.5 and 4.0.

pH values: Measurements of pH were made at 25° C., using a Beckman pH meter equipped with remote electrodes.

Statistical analysis: Calculation of the coefficients of correlation (r) and determinations of the significance of the data were made according to the method outlined by Paterson (11). In determining significance the "5 per cent" point was used. In other words, a coefficient of correlation was judged to be significant only when the data indicated that a similar degree of correlation could probably have been obtained purely as a matter of chance in less than 5 per cent of the trials.

RESULTS

The values for curd tension and curd surface area of the untreated, homogenized, enzyme-treated and base exchange milks are shown in table 1.

TABLE 1

The average values for curd tension and curd surface area (S/gm.) of all samples tested

Type of milk	No. of samples	Curd tension	Chambers-Wolman test				
			pH 6.0	pH 5.5	pH 5.0	pH 4.5	pH 4.0
		gms.	*S/gm.*	*S/gm.*	*S/gm.*	*S/gm.*	*S/gm.*
Untreated	11	37.7	5.8	6.3	10.7	27.5	50.9
Homogenized	10	18.0	6.3	6.9	15.0	39.4	52.3
Enzyme-treated	11	17.8	5.6	6.4	17.5	49.0	71.8
Base exchange	10	6.7	35.9	9.5	11.3	18.3	44.5

In table 2 are given the coefficients of correlation within each type of milk between the curd surface area at various pH levels and the curd tension.

TABLE 2

The correlation within types of milk between the curd surface area at various pH levels and the curd tension

Type of milk	Coefficient of correlation				
	pH of Chambers-Wolman test				
	6.0	5.5	5.0	4.5	4.0
	r	*r*	*r*	*r*	*r*
Untreated	+.03	+.32	−.16	−.27	−.18
Homogenized	+.01	+.49	−.27	−.02	−.08
Enzyme-treated	+.24	+.25	+.06	+.38	−.04
Base exchange	−.65*	−.67*	+.34	+.19	+.30

* Indicates coefficient of correlation was significant. Upon recalculation of these values after the elimination of three samples having curd tensions of 20, 14 and 17 grams the following values for *r* were obtained: pH 6.0, −.34; pH 5.5, +.14. Neither of these was significant.

A statistically significant relationship was observed in only two instances, namely in the case of base exchange milk when the determinations of curd surface area were carried out at pH 6.0 and pH 5.5. Since there was reason for suspecting that the apparent correlation in these two cases was due to the fact that at least three of the samples of base exchange milk had probably been undertreated, as indicated by the curd tension tests, these correlation coefficients were recalculated after the elimination of the samples having curd tensions of 20, 14 and 17 grams. After this procedure the correlation coefficient values dropped to −.34 and +.14 respectively, neither of which was of significance.

The relationship between curd surface area and curd tension within groups of various combinations of modified milks is shown in table 3. In calculating these values all samples of each type of milk included in the various groups were taken into account. First, all four types of milk were taken together and the coefficients of correlation calculated for the group as a whole. Then all possible combinations of three different types of milk were calculated. Considering all the various groups of milk, the relationships ranged from a significant negative correlation to a significant positive correlation with a good number of the values indicating no significant relationship.

There was no significant relationship between curd tension and curd surface area within the following types of milk: untreated, homogenized, enzyme-treated and base exchange milk. Under different conditions the correlation coefficients of these milks varied considerably, showing both positive and negative correlation, but in no instance were the values high enough to indicate that they might not have been arrived at through pure chance. The apparently significant relationship observed at first in base exchange milk (table 2) was evidently due to the presence of some un-

TABLE 3

The correlation within groups of various combinations of modified milks between the curd surface area at different pH levels and the curd tension

Types of milk	Coefficient of correlation				
	pH of Chambers-Wolman test				
	6.0	5.5	5.0	4.5	4.0
	r	*r*	*r*	*r*	*r*
Untreated Homogenized Enzyme-treated Base exchange	−.62*	−.51*	−.16	+.05	+.01
Untreated Homogenized Enzyme-treated	−.02	+.08	−.61*	−.56*	−.43*
Untreated Homogenized Base exchange	−.71*	−.58*	−.12	+.20	+.21
Untreated Enzyme-treated Base exchange	−.70*	−.61*	−.14	+.01	+.01
Homogenized Enzyme-treated Base exchange	−.72*	−.56*	+.41*	+.48*	+.38*

* Indicates coefficient of correlation was statistically significant.

dertreated samples, the elimination of which resulted in a finding of no significant relationship.

With regard to the correlation between curd surface area and curd tension within mixed groups of different types of milk the data were variable. In general, at pH levels of 6.0 and 5.5 a significant relationship was observed only in those groups which included base exchange milk. Conversely, at pH levels of 5.0, 4.5 and 4.0 the only significant negative correlation was observed in the group in which no base exchange milk was included. In the last group shown in table 3, including homogenized, enzyme-treated and base exchange milk, a significant negative correlation was observed at pH 6.0 and pH 5.5 while at pH levels, of 5.0, 4.5 and 4.0 the relationship was significantly positive.

In a previous paper (12) data were presented showing the varying response of some types of milk to changes of pH in the Chambers-Wolman test for curd surface area. It was pointed out that the method by which the milk had been treated in modification was apparently one of the most important factors involved since each type had some characteristics largely peculiar to itself. In the present comparison of curd tension and curd surface area it seems probable that the lack of a consistent relationship is due to the same factor, *i.e.*, the individual characteristics peculiar to each type of milk.

It would normally be expected with respect to good digestibility in milk that low curd tension would be associated with high curd surface area, or,

in other words, that there would be an inverse or negative relationship between the results of these tests. It now appears that this is not necessarily true since the data obtained in this investigation indicate that the degree of correlation depends to a very great extent upon the types of milk included in the tests. It would be possible by selective sampling to attain almost any desired degree of relationship.

In view of these findings it seems likely that such correlation as has been observed between curd tension and curd surface area has been largely coincidental. It is probable that curd tension and curd surface area are independent characteristics of milk and that each may be influenced or determined by different or loosely related factors.

SUMMARY

Within individual types of commercially modified milks there appears to be no significant correlation between curd tension and curd surface area.

Within mixed groups of various types of modified milk the relationship between curd tension and curd surface area is of variable significance and seems to depend upon the types of milk included in the particular group.

It appears that curd tension and curd surface area are independent characteristics of milk and that each may be influenced or determined by factors not closely related.

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A METHOD FOR THE ESTIMATION OF NICOTINIC ACID IN MILK[1]

E. A. BAILEY, JR.,[2] W. J. DANN, G. HOWARD SATTERFIELD
AND
C. D. GRINNELLS[3]

Since the discovery of the vitamin activity of nicotinic acid by Elvehjem *et al.* in 1937 (3), much attention has been given to the development of a chemical method for its estimation in biological materials. The König reaction (10) in which the pyridine nucleus, with cyanogen bromide and an aromatic amine, yields a substance which can be estimated colorimetrically, has been made the basis of the most satisfactory methods of estimation. In the application of the different methods to biological materials, it has been found difficult to obtain nicotinic acid extracts which are free from interfering materials. Perlzweig, Levy, and Sarett (13) have developed a method for determination of nicotinic acid in urine by which an almost colorless extract is obtained and this difficulty largely overcome. Dann and Handler (2) have adapted this method for estimation of nicotinic acid to animal tissue. The present study deals with the adaptation of the method to the estimation of nicotinic acid in milk.

The essentials of the method are: acid hydrolysis, removal of interfering substances by the use of Lloyd's reagent and lead hydroxide, and development of color by the method of Bandier and Hald (1).

METHOD

Preparation of extract: The whole milk is centrifuged for several minutes and the skim milk siphoned off. A 5-ml. sample of the skim milk is transferred to a large test tube (50 ml. capacity), graduated at 25 ml. Five ml. of concentrated hydrochloric acid (sp. gr. 1.19) are added and the tube placed in a boiling water bath for one hour. Charring and blackening occur. The tube is rotated occasionally to insure thorough mixing. This acid digestion completely hydrolyzes any nicotinamide which may be pres-

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[2] Submitted by E. A. Bailey, Jr., in partial fulfillment of the requirements for the degree of Master of Science, North Carolina State College of the University of North Carolina.

[3] Research Fellow, North Carolina State College; Associate Professor of Physiology and Nutrition, Duke University School of Medicine; Professor of Biochemistry, North Carolina State College; Associate, in charge of Dairy Research, North Carolina Agricultural Experiment Station, respectively.

ent. At the end of this time the tube is cooled, the contents made up to the mark with distilled water, and the solid material allowed to settle. A 15-ml. aliquot of the clear, dark brown supernatant liquid is transferred to a small beaker, 2 ml. of 15 N sodium hydroxide are added, and the solution cooled and the pH adjusted to 1 using the glass electrode. The solution is transferred, with a minimum of water, to an 18 × 135 mm.-Pyrex test tube containing 2 g. of Lloyd's reagent, the tube having previously been graduated at 16.2 ml. so as to contain 15 ml. of liquid in addition to the 2 g. of Lloyd's reagent. The tube is shaken for one minute, centrifuged, and the supernatant liquid poured off and discarded. The Lloyd's reagent is washed once by shaking with about 15 ml. of 0.2 N sulfuric acid, centrifuged, and the wash acid decanted. Ten ml. of 0.5 N sodium hydroxide are now added, the contents made up to the mark with distilled water, and the tube again shaken for one minute and centrifuged. The colored supernatant fluid is decanted into another Pyrex tube (18 × 135 mm.) containing 0.6 g. of finely powdered lead nitrate, the tube shaken and centrifuged. The resulting, practically colorless, supernatant liquid is decanted into a third tube. In order to remove any excess lead, the solution is made slightly alkaline by the addition of small amounts of K_3PO_4, using a single drop of phenolphthalein solution as indicator. The pH of the solution is then brought to approximately 4.5 by the cautious addition of 20 per cent orthophosphoric acid using Fisher Alkacid test paper or the glass electrode. The volume of fluid added must be kept to a few drops since the volume relationship is here being disturbed. The addition of two or three drops, however, results in only an insignificant error. The tube is centrifuged to throw down the new precipitate, and the supernatant fluid decanted for the König reaction.

Reagents for chemical reaction: Cyanogen bromide: A saturated solution of bromine water is titrated, in an ice bath, with 10 per cent sodium cyanide solution to complete disappearance of color, avoiding an excess of sodium cyanide. As as alternative method a 4 per cent aqueous solution of crystalline CNBr may be prepared. Either solution is stable for several weeks in the icebox.

Ten per cent KH_2PO_4 solution.

Metol (p-methylaminophenol sulfate): A saturated solution (about 5 per cent) is prepared immediately before using.

Development of color: A 5-ml. aliquot of the extract, equivalent to one ml. of skim milk, is transferred to an Evelyn macro-colorimeter tube. One ml. of 10 per cent KH_2PO_4 solution and 14 ml. of distilled water are added, making the volume 20 ml. This tube is designated as the *extract blank.* A second 5-ml. aliquot of the extract is placed in a large test tube, designated as *color development tube,* and 1 ml. of 10 per cent KH_2PO_4 and 3 ml. of water are added, making the volume 9 ml. To a second large test tube, designated as the *reagent blank,* is added 1 ml. of 10 per cent KH_2PO_4 and

8 ml. of water, making the volume 9 ml. These last two tubes are then placed in a water bath at 75–80° C. for five minutes. One ml. of cyanogen bromide solution is added to the warm tubes and they are again placed in the water bath at 75–80° C. for five minutes. The tubes are cooled under running water and 10 ml. of freshly prepared saturated metol solution are added to each, bringing the volume to 20 ml. They are then allowed to stand in the dark for one hour. At the end of this time the contents of the tubes are transferred to Evelyn macro-colorimeter tubes and all three tubes are read in the Evelyn photoelectric colorimeter. The readings are made using the No. 400 filter with the galvanometer set to read 100 with distilled water.

Calculations: The L values corresponding to the galvanometer readings for the three tubes are obtained from the chart accompanying the Evelyn Photoelectric Colorimeter. These L values are proportional to the optical density of the solutions. The L value obtained for the color development tube may be ascribed to three sources: the color of the extract, the color of the reagents, and the color resulting from the nicotinic acid reaction. An L value corresponding to the single factor, the quantity of nicotinic acid present, is obtained by subtracting the L value of the extract blank and the L value of the reagent blank from the L value of the color development tube. The number thus acquired, divided by the factor 0.0225, yields the nicotinic acid concentration in micrograms per ml. The factor, 0.0225, was obtained from standard solutions.

The procedure as outlined here is such that the final tube contains the equivalent of 1 ml. of skim milk. If a sample of a different size is taken, or if different dilutions are used, a dilution factor must also be introduced.

RESULTS AND DISCUSSION

Hydrolysis is carried out by digestion with hydrochloric acid. Dann and Handler (2) have pointed out the necessity for using rather small samples, about 0.5 g., for this digestion, in the analysis of tissue. The use of larger samples of certain tissues yields apparent values which are smaller as the size of the sample is increased. A similar behavior is found in analysis of milk. For example: with one sample from which 10 ml. and 5 ml. portions were taken for digestion, the estimated nicotinic acid was 1.16 and 1.34 μg. per ml., respectively, with a second sample, 1.69 and 1.72, and with a third sample, 1.33 and 2.02. With samples smaller than 5 ml. the total amount of nicotinic acid involved in the color development is too small to obtain an estimate with any degree of accuracy.

As was pointed out by Perlzweig, Levy, and Sarett (13) and by Dann and Handler (2), it is essential, in the determination, to obtain almost complete decolorization of the extract. This point is illustrated in table 1 in which a comparison is given of the estimated nicotinic acid content of a sample of milk when almost complete and when only partial decolorization

was obtained with the Lloyd's reagent and lead salt treatment, and also when charcoal was used as the decolorizing agent. The differences in degree of decolorization, using the Lloyd's reagent and lead salt treatment, were obtained by varying the thoroughness with which the lead nitrate was mixed with the extract. The amount of colored material remaining in the extract is shown by the L value of the extract blank. When the color remaining in the extract blank gives an L value much greater than 0.0223, unreliable results are generally obtained.

TABLE 1

The effect of incomplete decolorization upon the estimation of nicotinic acid
(All determinations are on the same sample of milk)

Decolorizing agent	L value of extract blank	Estimated nicotinic acid
		μg. per ml.
Lloyd's and lead	0.0223	1.59
Lloyd's and lead	0.2366	4.44
Lloyd's and lead	0.4440	6.16
Charcoal (av. of 4 determinations)	0.1265	7.01

In this connection it is of interest to note the report of Melnick and Field (12) with regard to the advisability of addition of the aromatic amine to the extract blank. These authors point out that, although the addition of the amine to the extract blank results in the development of a color indistinguishable from that obtained with nicotinic acid, these side reactions do not occur in the presence of cyanogen bromide in the actual development of color for the nicotinic acid. They state that, consequently, the amine should not be added to the extract blank. Melnick and Field (12) report the results for milk, estimated by the two methods, as follows: with addition of the amine (aniline) to the extract blank, 0.12 mg. per cent; without addition of the amine, 0.44 mg. per cent. Expressed in micrograms per ml. the values are 1.2 and 4.4, respectively.

By the method used in the present study, the interfering substances involved are removed from the extract by the Lloyd's reagent and lead salt treatment, and the average value obtained is 1.46 μg. per ml. This value agrees more closely with the value obtained by Melnick and Field (12) when the amine was *added* to the extract blank. It is somewhat lower than values obtained by Kodicek (9), using the method of Harris and Raymond (7), in which the amine (p-aminoacetophenone) is added to the extract blank. The values obtained by Kodicek are 1–5 μg. per ml. with an average of 3.

Recovery of nicotinic acid added to milk is shown in table 2.

The data obtained from determinations on 24 samples of milk, run in quadruplicate, were analyzed statistically. This analysis gives the standard error of the means of four determinations to be 0.105, or 7.2 per cent of

TABLE 2

Recovery of nicotinic acid

Sample No.	No. of determinations	μg. per ml. added	μg. per ml. found	Per cent of total nicotinic acid found
I	4	0	0.94	———
	2	2	2.93	99.7
	2	4	4.64	93.9
II	6	0	1.67	———
	2	1	2.64	98.9
	2	2	3.88	105.7
	2	4	5.44	95.9

the average normal value obtained, 1.46. The limits of accuracy of the method seem satisfactory when one considers the small amounts of nicotinic acid present and the complexity of the determination.

The results of weekly analysis, during the month of January, 1941, of the milk of six Ayrshire cows from the North Carolina Experiment Station herd are given in table 3. Cows 1–5 were maintained on stock rations and the samples taken at the time of regular milking. Cow No. 6, which was in the eighth month of gestation, was not being milked regularly, and only sufficient milk for the nicotinic acid determinations was obtained. The values obtained from determinations on the milk of cow No. 6 are not included in the average value for normal cows. Each value in the table is an average of four determinations. The average for normal cows during this period was 1.46 micrograms per ml.

TABLE 3

Nicotinic acid content of milk from Ayrshire cows on stock ration

Date	Cow No. 1	Cow No. 2	Cow No. 3	Cow No. 4	Cow No. 5	Cow No. 6
	μg./ml.	μg./ml.	μg./ml.	μg./ml.	μg./ml.	μg./ml.
Jan. 7 ———	2.12	1.42	1.48	1.32	1.40	2.16
Jan. 13 ———	1.39	1.42	1.60	1.57	1.80	2.78
Jan. 20 ———	1.38	1.12	1.47	1.47	1.89	2.26
Jan. 27 ———	1.45	1.66	0.81	1.00	1.42	2.33
Average ———	1.58	1.40	1.34	1.34	1.63	2.38

Average of normal cows, Nos. 1–5, 1.46.

A comparison of the results obtained in this study with some of the values obtained by chemical methods, as reported in the literature, is given in table 4.

We suggest that the results of Melnick and Field (11) and of Kodicek (9) are too high due to incomplete decolorization of the extract.

The low values obtained are of interest in view of the fact that milk has long been considered of great importance in a pellagra-preventing diet.

TABLE 4

Comparison of values obtained by different investigators for the nicotinic acid content of milk

		µg. per ml. fresh milk
Swaminathan (14)	Skim milk powder (10.53 mg.%)	0.90–1.00*
Melnick and Field (11)	Fresh milk (.45 mg.%)	4.5
Kodicek (9)	Fresh milk (1–5 µg./ml., average 3)	3
Kodicek (9)	Dried milk (25 µg./g.)	2.88–3.62†
Present study	Fresh skim milk	1.46

* Skim milk powder 8.5–9.5% of original skim milk (16).
† Whole milk powder 11.5–14.5% of original milk (16).

Goldberger and his collaborators (4, 5, 6, 15) have found milk to give partial protection and sometimes complete protection from blacktongue in dogs and pellagra in man for periods as long as a year when preventive tests were made. In one pellagra test, complete protection was afforded by 40 ounces of buttermilk daily, yet on the basis of our figures for milk and those of Dann and Handler (2) for cornmeal, it is clear that milk contains less nicotinic acid than the equi-caloric quantity of cornmeal which must have been displaced from the diet.

There are two possible explanations of this paradox. First, that the chemical method of estimating nicotinic acid in milk fails to detect all the nicotinic acid. Second, that when considerable quantities of milk are included in the diet, the intestinal flora is so altered that a significant amount of nicotinic acid is synthesized by the intestinal microorganisms, and then absorbed from the intestine. The second suggestion seems to us to be much more probable than the first.

SUMMARY

A method is given for the estimation of nicotinic acid in milk.

The results of weekly analysis of the milk of six Ayrshire cows during the month of January, 1941, are given. The average nicotinic acid content of the milk from normal cows is found to be 1.46 micrograms per ml.

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THE LETHAL EFFECTIVENESS OF ULTRA VIOLET RAYS APPLIED TO MILK*

G. C. SUPPLEE, G. E. FLANIGAN AND O. G. JENSEN

The Borden Company, Biological and Chemical Research Laboratories, Bainbridge, New York

Biologists have long recognized ultra violet radiation as a lethal agent for the destruction of bacteria. Its application for sterilization or the reduction of bacterial contamination of various substances is limited however, by the low penetrating power of the active radiation. The common gases of the air, water vapor, substances in solution, colloidal suspensions, and obviously solids, exert a general or specific screening effect on the active rays. As a consequence, such bacterial reduction as may be accomplished by spectral energy of this character must take place at or near the surface. Accordingly, one of the essentials in any problem of adaptation of this lethal principle is to provide surface exposure. The inherent principles operative in the mechanics of flowing fluid films of certain types, present a degree of surface exposure warranting studies designed to determine the utility and limitations of ultra violet energy for the destruction of bacteria in milk. The desirability of such experimentation has also been accentuated by the availability of improved and more potent emission sources. Pertinent results from practical but well controlled techniques obtained from commercial milk representative of the day to day receipts from a country receiving plant, are recorded hereinafter.

EXPERIMENTAL

One of the basic features of the technique employed in these studies involves flowing milk films, the characteristics of which could be duplicated at will by the simple expedient of originating the film from a horizontal capillary slot contiguous to the supporting surface and positioned to allow exit flow at an angle to the force of gravity. Flowing films thus projected onto a smooth surface can be controlled to a precise degree in regard to thickness during a given distance of travel, film capacity or rate of flow and uniformity of flow characteristics at the free interface. Speed of travel may also be controlled by varying the capacity and thickness of the film and the temperature. Figure 1 illustrates the equipment used for forming films with a 50-inch vertical travel and width up to 18 inches. This unit is provided with a baffled water jacket permitting regulation and control of the temperature of the flowing film if desired. Figure 2 illustrates similar equipment

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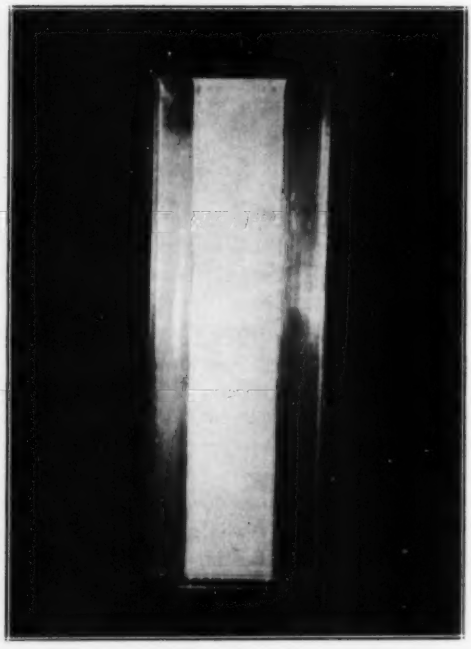

FIG. 1. Smooth flowing film used for determining lethal effect of ultra violet rays.

FIG. 2. Milk film flowing over quartz window used for determining comparative transmission of ultra violet rays.

provided with quartz windows for determining ultra violet or other radiation transmitted through the flowing film as it passes over the quartz window.

The sources of ultra violet radiation were mercury arcs and lamps of standard or special construction furnished by The Westinghouse Electric and Manufacturing Company. The arc tubes were approximately 22 inches long and one-half inch in diameter. These tubes, when used singly, were placed vertically in front of the flowing milk film at various distances depending upon the experimental plan, and positioned equi-distant laterally from the edges of the film and equi-distant longitudinally from the top and bottom. When a plurality of arcs were used, they were positioned horizontally with equal spacing between the tubes depending upon the number used and the length of the film irradiated.

Each arc operating at a given voltage and amperage emitted radiation of different spectral character, qualitatively and quantitatively. The relative intensity of the emissions from the different arcs, as measured through quartz and a two inch aperture by a metered tantalum photoelectric cell, (1, 2), was of the comparative magnitude of 148, 87, 18 and 4 at a 12-inch distance. The peak of sensitivity of this particular photo-cell was in the region, of 2550–2600 Å, with very slight registration as low as 2000 Å and a cut-off at approximately 3000 Å. By placing the photo-cell back of the quartz window over which milk was allowed to flow, as a smooth film (fig. 2), the intensity of the radiation transmitted by films of different capacity was readily obtained.

Chart 1 shows typical results obtained from each of the radiation sources studied, from which it is to be noted that there is substantially a straight line relationship correlating the intensity of the transmitted radiation with the film capacity, when employing logarithmic scales. It will also be noted that the order of magnitude of the transmitted radiation is not proportional to the emission intensity of the different arcs. This is accounted for by the fact that the spectral quality of each arc is of different character and the milk films selectively absorb the incident radiation in varying degrees. The salient characteristics of the radiation from the different sources may be briefly summarized as follows: Arc No. 1 with a radiation intensity of 148 has a strong 2537 Å emission, as high as 85 to 94 per cent of the total output; arc No. 2 with a radiation intensity of 18 has substantially the same characteristics as arc No. 1, but at less intensity, practically no short wave radiation is emitted by this arc however; arc No. 3 has substantially the same characteristics as arc No. 2 but with less intensity; arc No. 4 with a radiation intensity of 87 yields substantially none of the 2537 Å wave length but does emit very strong radiation in the 2200–2300 Å region, probably 80 per cent or more of the total energy output.

The bacteriological data summarized hereinafter were obtained over a period of years. All milks involved in the studies were representative of

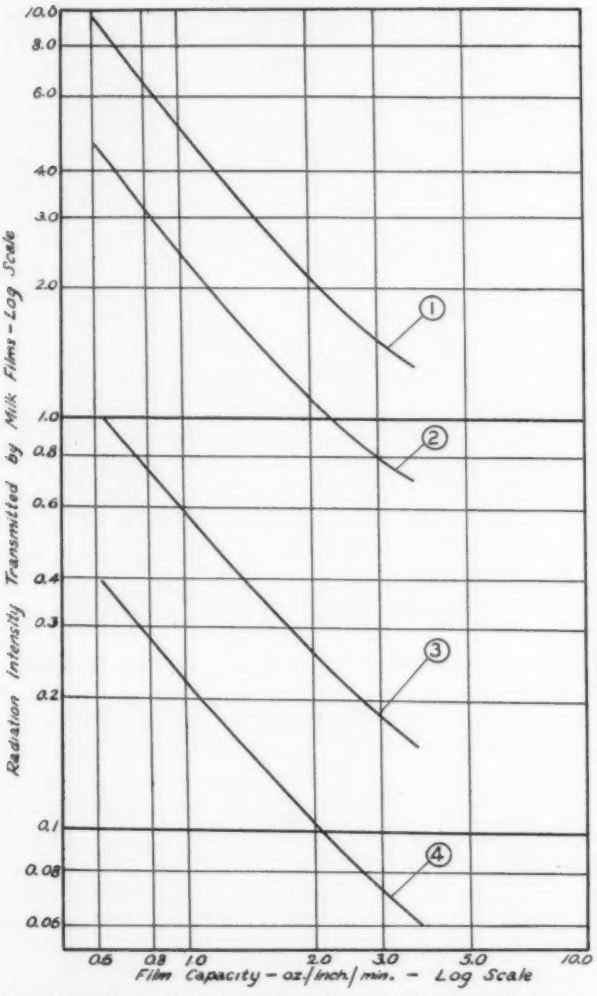

CHART 1. Transmission of ultra violet radiation through milk films. (Tantalum photo cell measurements.) 12 inches from arc to quartz or milk.

Arc (1)	radiation	intensity	148
Arc (2)	"	"	18
Arc (3)	"	"	4
Arc (4)	"	"	87

the daily receipts of mixed milk from a "Grade B" country plant in New York State. The composited records shown in graphical form are made up from hundreds of determinations with numerous different samples con-

tributing to a single result in the comparable relationships shown in the individual graphs. Since our objective was a thorough appraisal of the lethal value of ultra violet radiation applied to commercial milk, rather than a desire to demonstrate extreme results under conditions which would hold no promise of reduction to practise, it is believed that the graphical presentation most satisfactorily establishes the merits of the principles under investigation.

For all test runs at least two or three control samples of the untreated milk were taken from the supply tank located immediately above the film-forming member of the apparatus during the period of operation. Subsamples of the treated milk, frequently five or more, were taken at intervals during the course of the individual run. All platings were made in triplicate with Tryptone Glucose Agar, incubated at 37° C. In order to avoid discrepancies due to latent effects following irradiation, platings were made immediately and in practically all instances the agar was in the plates within three to five minutes after treatment.

The comparative degree to which differences in the spectral character and intensity of the various radiation sources were lethally effective when applied to milk films under conditions previously described, is shown in chart 2. The relative bactericidal results shown by graphs 1, 2, and 3 fall in the expected order as might be anticipated from the intensity of the incident radiation. Graph No. 4 obtained with the arc having a comparatively strong radiation intensity of 87 as measured by the tantalum photo-cell, shows a relatively inefficient bactericidal effect at the lower film capacities, but an unexpectedly high efficiency at the higher film capacities. Since this arc emits a high proportion of relatively short irradiation in the 2200–2300 Å region, other detailed studies with this source were carried out, typical results from which are shown in chart 3.

Graph No. 1 of chart 3 was constructed from data obtained by exposing a flowing film maintained at uniform capacity during a sequence of irradiation periods until a total exposure time of 28 seconds had accumulated. The initial exposure period of 8 seconds resulted in a greater reduction in bacteria count than was shown after more extended periods. This phenomenon was entirely contrary to any experience encountered with the other radiation sources. In order to study this matter further, stationary films of the same milk were prepared by allowing the film-supporting surface to drain until only a thin adhesion layer substantially 0.02 mm. in thickness, remained. Graph No. 2 in chart 3 shows the results obtained upon exposing such films to the short wave radiation for periods up to 34 seconds. The results generally confirm those obtained by irradiation of the flowing films, a greater lethal effect being manifested during the first few seconds exposure, this reduction in count being nullified on longer exposure with counts even in excess of the original untreated milk, after a period of 12 to 20 seconds.

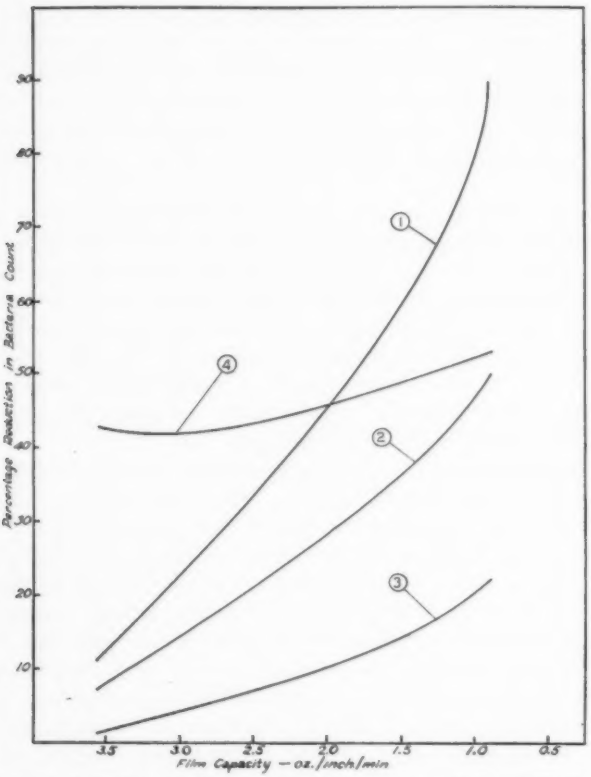

CHART 2. Lethal effect of different radiation sources applied to milk films.

Distance of film flow	50 inches
Film width	16 inches
Arc to film	12 inches
Exposure time (varies with film capacity)	3.0–10 secs.
Film thickness (varies with film capacity)	
Curve (1) Arc radiation intensity	148
Curve (2) " " "	18
Curve (3) " " "	4
Curve (4) " " "	87

Thereafter an increase in lethal effectiveness as manifested by reduction in count became apparent. The full explanation of these observations with adequate supporting data is not now available. It is significant, however, that they support in principle, the observations of Coblentz and Fulton (3) and Hollaender *et al.*, (4, 5, 6) who have reported evidence of a bacteria stimulating effect resulting from sub-lethal doses of monochromatic ultra violet radiation. The relationships shown in the graphs could not be dupli-

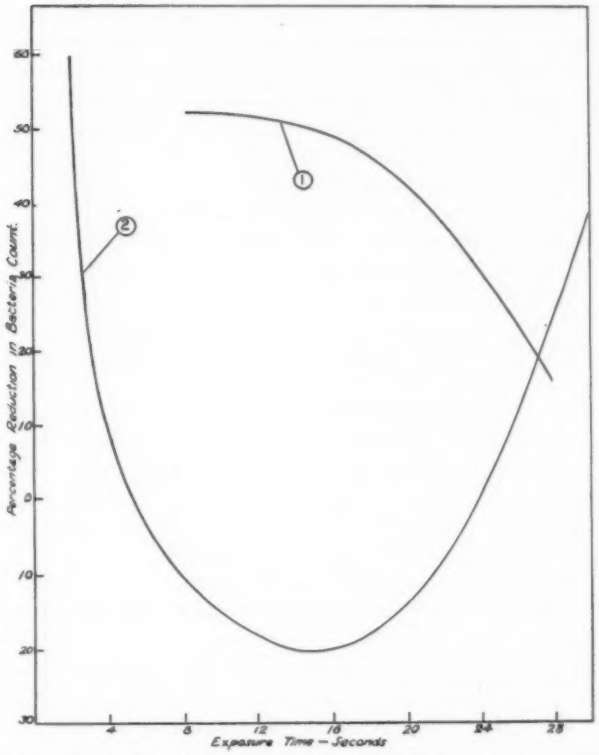

CHART 3. Lethal effect of short ultra violet radiation (arc No. 4) on stationary and flowing milk films.

	(1) Flowing films	(2) Stationary films
Film surface	Smooth	Smooth
Distance of film flow (ins.)	50–150	None
Film width (ins.)	3	3
Film capacity (oz./ins./min.)	1.62	None
Radiation source	Arc No. 4	Arc No. 4
Arc to film (ins.)	3.25	3.25
Film thickness (mm.)	0.2–0.25	0.02

cated at will from time to time with different milks. In some instances an increased count in the flowing film represented a two-fold increase in the count of the original milk; in a few instances a progressive decrease in count was obtained with increasing exposure time; and in other cases reduction in counts up to 90 or 95 per cent was obtained on momentary exposure of only a few seconds with no evidence of subsequent increase in count upon continued exposure.

These characteristically erratic results were generally obtained with the arc emitting a high proportion of short wave lengths in the absence of 2537 Å radiation. Such wave lengths are absorbed at the free interface of the flowing film to a much greater degree than longer wave lengths. It may be postulated therefore that since the lethal effect of short radiation is known to be greater than that of longer wave lengths provided it reaches the organism, the destructive action noted took place at or substantially at the free interface. Whereas, those organisms below the free interface received only sub-lethal doses, but did receive an increment of screened radiation sufficient to stimulate greater viability and growth in artificial media. This evidence of apparent stimulation may have been due in fact, to the jarring apart of aggregates of bacteria without destruction of the individual organism. Such a conjecture, however, is not supported by the observations by other investigators to which reference has already been made.

It is not to be assumed that the erratic results obtained from the short ultra violet radiation are characteristic examples of the bactericidal efficacy of all ultra violet energy when appropriately applied to milk. A relatively high and consistent reduction in bacteria count may be obtained under conditions readily duplicable at will. The degree of bacterial reduction in milk is, however, dependent not only upon the character and intensity of the incident radiation, but also upon the manner in which it is applied. Certain principles which influence its lethal effectiveness are exemplified by the data which follow.

Chart 4 illustrates the relative bactericidal effect obtained by a plurality of arcs (No. 3) with the weakest radiation intensity of any of those used throughout this work. Bacterial reduction is correlated with the time of exposure of flowing and stationary films, the latter results being included as a basis of reference and comparison. The flowing films (graph No. 2) show an average percentage reduction varying from 35 per cent to in excess of 95 per cent during exposure periods from about 2.5 seconds to 16 seconds, the capacity of the films being inversely correlated with the exposure time. These results, as compared with those obtained from the stationary films exposed for comparable periods and which represent an adhesion layer only (graph No. 1), are of significance in illustrating inherent principles wherein the effect of the reactive energy is confined to, or near the surface. Notwithstanding the substantially thinner layer of milk exposed as a stationary adhesion film, the reduction in bacterial content is commensurately less than was obtained in the flowing film of much greater thickness, for comparable time exposure of the milk mass. It is to be concluded therefore that the flowing films inherently present a greater exposure per unit volume at the free interface than the stationary films, thus the lethal property of the incident radiation is more effectively utilized. Objective results of a practical character in which this principle is operative have also been shown in the

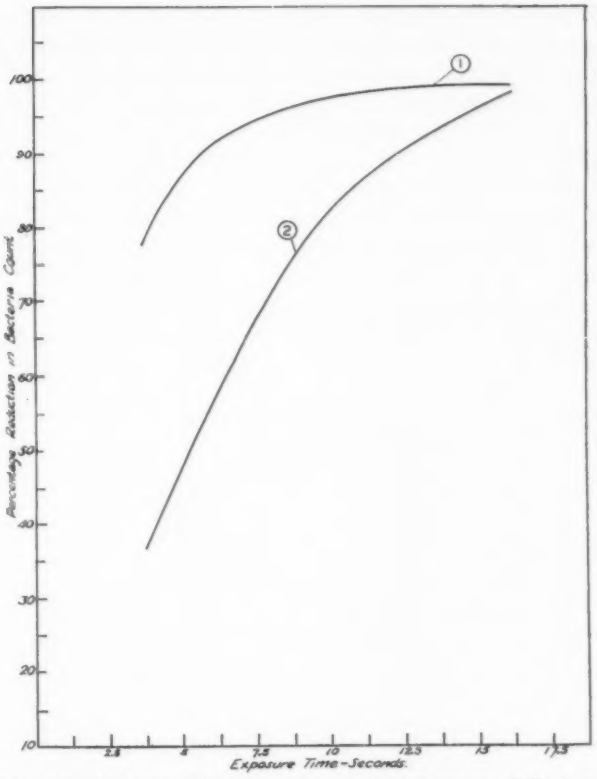

CHART 4. Lethal effect of ultra violet radiation on stationary and flowing milk films.

	(1) Stationary films	(2) Flowing films
Film surface	Smooth	Smooth
Distance of film flow (ins.)	None	50
Film width (ins.)	16	16
Film capacity (oz./in./min.)	None	0.9–3.6*
Radiation source	Arc No. 3 (20 units)	Arc No. 3 (20 units)
Arc to film (ins.)	3.25	3.25
Film thickness (mm.)	0.02	0.2–0.4†

* Varies with exposure time.

† Varies with film capacity.

irradiation of milk for vitamin D activation (7). The results shown by these data illustrate primarily, a principle influencing the lethal effectiveness of ultra violet radiation as applied to milk, but do not represent the greatest degree in bacterial reduction which may be obtained by this means. However, before presenting other considerations, data obtained from films flowing over smooth and corrugated surfaces should be examined.

Chart 5 shows the comparative bacterial reduction in milk films of varying capacity when exposed as a smooth film projected as heretofore described and as a film flowing over a standard two-inch tubular cooler surface. The distance of vertical travel of the smooth film was 27.5 inches; the projected

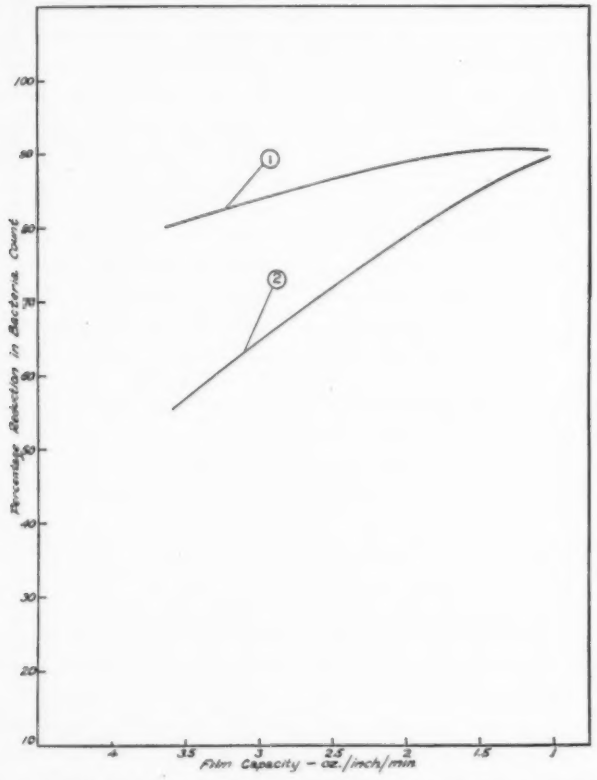

CHART 5. Lethal effect of ultra violet radiations on smooth and corrugated films.

	(1) Smooth films	(2) Corrugated films
Film surface	Smooth	Corrugated*
Distance of film flow (ins.)	27.5	41.5†
Film width (ins.)	16	16
Film capacity (oz./in./min.)	Variable	Variable
Radiation source	Arc No. 3 (12 units)	Arc No. 3 (12 units)
Arc to film (ins.)	3.25	3.25
Exposure time (secs.)	Variable	Variable
Film thickness (mm.)	Variable	Variable

* Cooler surface.

† 27.5 inches projected vertical distance.

vertical length of the corrugated surface was also 27.5 inches. However, the actual distance of film travel over the corrugated surface was 41.5 inches, or substantially 50 per cent greater than the distance travelled by the smooth film. It might be expected that this greater distance of film travel would contribute to greater exposure per unit of volume at the free interface and thus enhance the lethal effectiveness of the incident rays, causing a greater reduction in bacteria count. However, an examination of the graphs in chart 5 shows the reverse to be true, a greater reduction in count being obtained from the smooth films traveling a lesser distance than the corrugated films.

One of the reasons for this result is probably illustrated by the scale diagrams shown in chart 6. Figure 1 shows the variable and irregular thick-

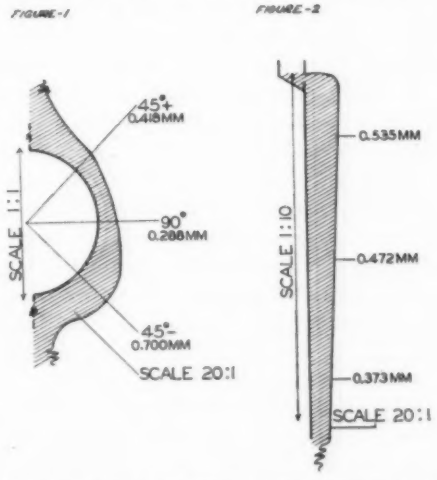

CHART 6. Thickness of flowing milk films as affected by contour of surface. (Temperature 68–70° F.; Film capacity 3.55 oz./inch/min. ± 0.15.) Figure 1. Two-inch tube of cooler assembly. Figure 2. Smooth metal surface—50 inches. (Film from capillary slot at right angle to gravity.)

ness of the film traveling over a two-inch corrugation of a tubular cooler at a distance approximately 10 inches from the point of origin. It is to be noted that the transverse section of the film tends to assume a characteristic raindrop shape with the thinner section of the film at, or a little above, the horizontal plane of intersection, whereas the thicker portion is about 45° below the horizontal intersection. Comparison of the shape of the transverse section of the film flowing over the two inch contour, with the uniform and progressively tapering wedge-shaped transverse section of the film projected from the capillary slot, flowing over a smooth surface, (figure 2) readily shows that greater surface exposure at the interface per unit volume does

not necessarily prevail in the corrugated film, notwithstanding the greater linear distance traveled. An analysis of the interacting forces of gravity, friction and surface tension readily reveal the reasons for the differences in thickness and character of the two types of films. [The actual film thickness measurements were made by the method described by Beck (8).] A further explanation of the lower bactericidal result obtained with the corrugated films is probably due to the fact that a higher proportion of the energy impinged on the surface at angles substantially less than normal, a condition which increases reflection and otherwise reduces the efficiency of the incident radiation.

Since ultra violet radiation is a form of energy, as is heat, it is desirable to compare the bactericidal effectiveness of each of these forms of energy as applied to milk; such comparative data are shown in charts 7 and 8. Graph No. 1 of chart 7 shows a normal percentage reduction curve obtained by treating milk in the Electro-pure pasteurizer at various temperatures from 162° F. to 195° F. The percentage reduction figures through this range increase progressively from about 96 per cent to 99.9 per cent. These same heat treated milks, cooled, and subsequently subjected to ultra violet radiation from arc No. 1 with a radiation intensity of 148, show a slight but measurably consistent further reduction in bacteria count (computed to the original raw milk basis) as shown in graph No. 2. However, the comparative efficiency of the ultra violet energy applied to the previously heated milks is more clearly revealed in graph No. 3. A substantially consistent 60 per cent reduction was effected by the radiant energy applied to the milks heated through the 162° F. to 185° F. temperature range. Thereafter the efficiency of the radiant energy fell off rapidly. These relationships and comparisons obviously present stimulating problems of a strictly bacteriological character, as it is apparent that certain species or individual organisms inherent in the normal milk flora are not completely eliminated by this integrated application of thermal and radiant energy.

Chart 8 shows the data obtained by irradiating milk with the most lethal energy source used throughout this work (arc No. 1), during elevation of the temperature to various levels throughout the range 80° F. to 180° F. Heating of the flowing milk film was accomplished by electrical means described elsewhere by Supplee and Jensen (9). The time of exposure to the radiant energy concurrent with the elevation in temperature for each of the milks did not exceed 0.7 seconds. Graph No. 1 shows the percentage reduction curve obtained by the thermal treatment only and represents, in so far as we are aware, the first correlated data of this character wherein the time factor is substantially eliminated. The influence of temperatures up to about 120° F. applied for a fraction of a second apparently caused an increase in bacterial count, but a lethal action prevails thereafter with progressing effectiveness as the temperature is increased. Graphs No. 2 to No. 5

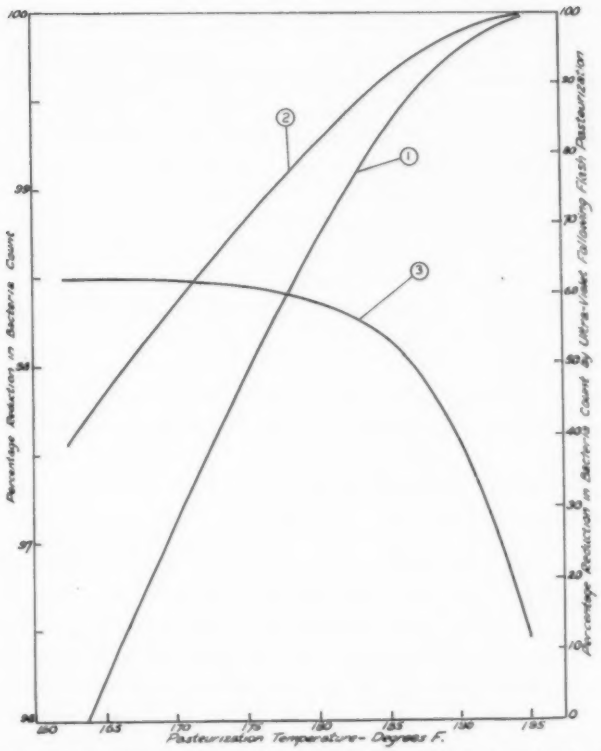

CHART 7. Lethal effect of ultra violet radiation following flash pasteurization.

(1) Flash pasteurization (Electro pure apparatus).

(2) Flash pasteurization (Electro pure apparatus) followed by ultra violet radiation.

Film surface	Smooth
Distance of film flow (ins.)	50
Film width (ins.)	16
Film capacity (oz./in./min.)	1.62
Radiation source	Arc No. 1
Arc to film (ins.)	12
Film thickness (mm.)	0.2–0.25
Exposure time (secs.)	7.6

(3) Lethal effect of ultra violet on flash pasteurized milk.

represent the results obtained from each of the four different radiation sources wherein their respective emissions were applied during elevation of the temperature. These results indicate that the combined lethal effect of the two forms of energy is primarily additive, the increment of the total bactericidal result contributed by each becoming apparent only as the other component contributes a secondary or lesser effect. This relationship is best

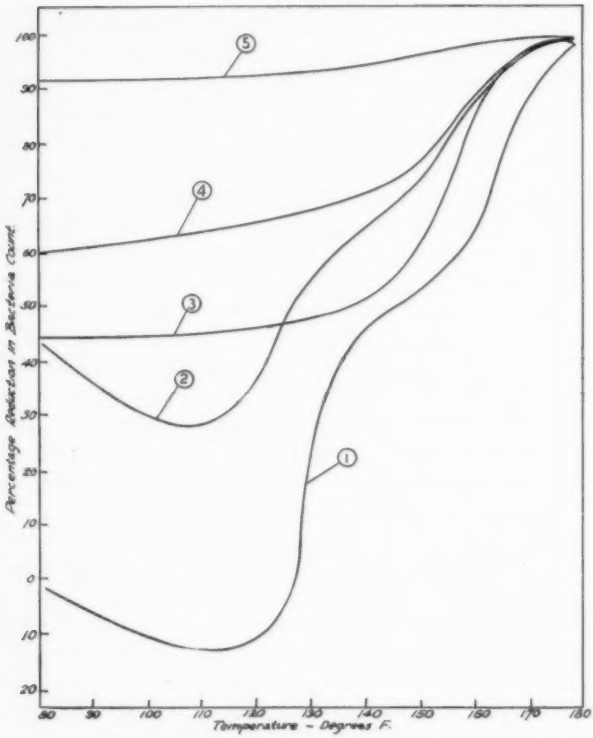

CHART 8. Lethal effect of ultra violet radiation simultaneously applied with flowing film heat treatment.

Distance of film flow (ins.)	12
Film width (ins.)	6
Film capacity (oz./in./min.)	3.6
Arc to film (ins.)	3.25
Exposure time (secs.)	0.7
Film thickness (mm.)	0.35–0.45

Curve (1) S–J Electric Heater
Curve (2) " " " + Arc No. 3 (Intensity 4)
Curve (3) " " " + Arc No. 4 (Intensity 87)
Curve (4) " " " + Arc No. 2 (Intensity 18)
Curve (5) " " " + Arc No. 1 (Intensity 148)

illustrated by a comparative analysis of graphs 1, 2 and 5. The substantially horizontal line of graph 5 representing 90 per cent reduction or more by the radiation from arc No. 1, especially throughout the range of lower temperature treatments in which range temperature alone caused an increase in counts, is typical of the degree of reduction, which has been consistently

obtained from this source throughout extended experiments in which no heat treatment was involved.

The various data and inter-relationships as presented illustrate certain principles involved in the study and application of ultra violet energy as a lethal agent for the destruction of bacteria in milk. Further refinement in the development of preferred methods of application must necessarily take these principles into account. The differences in the spectral characteristics of the radiations from the arcs included in this study, correlated with their lethal effectiveness as applied under the conditions described, clearly indicate a preferred specificity of energy distribution and intensity as essential for a high bactericidal effect when applied to milk.

SUMMARY

1. The lethal effectiveness of ultra violet energy applied to smooth flowing milk films is dependent upon the intensity and spectral characteristics of the radiation employed.

2. A greater bactericidal effect was obtained by ultra violet radiation applied to smooth flowing milk films than was obtained from films flowing over a corrugated cooler surface.

3. The effectiveness of the lethal radiation was relatively greater per unit volume of milk when applied to flowing films than when applied to stationary films having the thickness of an adhesion layer only.

4. Short ultra violet radiation predominantly in the 2200–2300 Å region gave erratic bactericidal results with evidence that sub-lethal doses may cause stimulation.

5. The total lethal effect of ultra violet energy and elevated temperatures simultaneously applied for less than one second appears to be an additive process.

6. Percentage reduction in bacteria counts of raw mixed milk in excess of 90 per cent and frequently up to 95 to 98 per cent may be obtained with a high degree of regularity by preferred methods of applying ultra violet radiation of appropriate intensity and spectral characteristics.

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REPORT OF THE STUDENTS' NATIONAL CONTEST IN JUDGING DAIRY CATTLE

Memphis, Tenn., October 11, 1941

The students' national contest in judging dairy cattle was held at the National Dairy Show, Memphis, Tennessee, on October 11. Twenty-four teams were entered.

The results of the contest were announced at a banquet held at the Gayoso Hotel on the evening of October 12. Dr. Jacob, Dean of the College of Agriculture of the University of Tennessee, and Chief O. E. Reed of the U. S. D. A. Bureau of Dairy Industry were the speakers. The Queen of the Dairy Show and her maids of honor attended the banquet.

The team from Iowa State College won the contest and were awarded permanent possession of the National Dairy Association cup as this was the third time they had won it. They were awarded the Hoard's Dairyman sweepstakes cup for the second time.

The Texas A. & M. College team placed second and were given possession for one year of the glory trophy awarded by the J. B. Ford Company.

Lyle Jackson was high man in the contest and received a gold medal from the National Dairy Association, a gold watch from the J. B. Ford Company, a pen and pencil set from the Country Gentleman and a cane from Successful Farming.

Lon McGilliard of Oklahoma placed second and received a radio from Starline, Inc., a silver medal from the National Dairy Association and a cane from Successful Farming.

Ralph Porterfield of Ohio placed third and received a bronze medal and a cane.

The Kansas team placed first in judging Ayrshires and were awarded the traveling trophy by the Ayrshire Breeders' Association, together with silver goblets. Russell Lyons of Iowa was high man. Ohio was first in Brown Swiss with Ralph Porterfield of Ohio high man. The winning team received a new traveling trophy with a built-in Swiss bell. The members of the team and high man received pen and pencil sets. Iowa placed first in judging Guernseys with J. B. Miller of Mississippi high man. The team was awarded the large traveling silver Guernsey cream can and the members of the team and high man received small cream cans. The Georgia team placed first to win the Holstein-Friesian Association of America silver cup and with the high man, Jack Paulson of Nebraska, were awarded gold medals. The team from Kansas was first in judging Jerseys, winning the bronze Jersey cow together with gold medals for the team. To Oscar Wesson of Purdue, the high man in Jerseys, went the coveted $300.00 scholarship from the American Jersey Cattle Club.

The following is a list of the individuals and teams who won high standings in the contest:

ALL BREEDS

INDIVIDUALS

1.	Lyle Jackson, Iowa State College	1804.4
2.	Lon McGilliard, Oklahoma A. & M. College	1795.9
3.	Ralph Porterfield, Ohio State University	1791.8
4.	H. B. Hale, Texas A. & M. College	1768.8
5.	J. F. Cavanaugh, Kansas State College	1762.8
6.	Jack Paulson, University of Nebraska	1760.8
7.	J. D. Miller, Mississippi State College	1760.4
8.	Max Dawdy, Kansas State College	1757.2
9.	Oscar Wesson, Purdue University	1734.6
10.	Alfred Huseth, University of Minnesota	1714.0

TEAMS

1.	Iowa State College	5183.4
2.	Texas A. & M. College	5168.9
3.	Kansas State College	5141.7
4.	University of Nebraska	5114.4
5.	Oklahoma A. & M. College	5045.8
6.	Georgia State College	5036.4
7.	University of Kentucky	4981.8
8.	Ohio State University	4972.0
9.	Mississippi State College	4925.2
10.	University of Minnesota	4895.9

AYRSHIRES

INDIVIDUALS

1.	Russell Lyons, Iowa State College	381.7
2.	William Hastnell, University of Nebraska	381.3
3.	J. F. Cavanaugh, Kansas State College	380.6
4.	H. B. Hales, Texas A. & M. College	379.6
5.	Walter Harvey, Oklahoma A. & M. College	379.1
6.	J. C. Kay, Texas A. & M. College	378.9
7.	Jack Paulson, University of Nebraska	378.6
8.	J. R. Weis, Kansas State College	378.4
9.	Alfred Huseth, University of Minnesota	378.0
10.	Lyle Jackson, Iowa State College	376.7

TEAMS

1.	Kansas State College	1133.9
2.	University of Nebraska	1125.4
3.	Iowa State College	1116.8
4.	Oklahoma A. & M. College	1110.2
5.	Texas A. & M. College	1104.8
6.	University of Minnesota	1097.7
7.	Purdue University	1097.0
8.	New Jersey State College	1096.5
9.	University of New Hampshire	1093.1
10.	Texas Technological College	1088.9

BROWN SWISS

INDIVIDUALS

1.	Ralph Porterfield, Ohio State University	382.2
2.	Harold Hansen, University of Nebraska	360.3
3.	Howard H. Smith, University of Illinois	354.1
4.	Lyle Jackson, Iowa State College	353.3
5.	Albert Hall, Michigan State College	353.0
6.	H. B. Hales, Texas A. & M. College	352.3
7.	Stokes Homan, New Jersey State College	351.2
8.	Lon McGilliard, Oklahoma A. & M. College	347.3
9.	Robert Russell, University of New Hampshire	346.7
10.	J. F. Cavanaugh, Kansas State College	346.5

TEAMS

1.	Ohio State University	1020.6
2.	Iowa State College	1012.9
3.	University of Nebraska	995.1
4.	University of New Hampshire	971.5
5.	Texas A. & M. College	967.5
6.	University of Kentucky	963.9
7.	Kansas State College	962.8
8.	University of Illinois	960.6
9.	Georgia State College	944.0
10.	New Jersey State College	939.6

GUERNSEYS

INDIVIDUALS

1.	J. D. Miller, Mississippi State College	385.0
2.	Lyle Jackson, Iowa State College	383.8
3.	Lon McGilliard, Oklahoma A. & M. College	382.6
4.	Gene Campbell, University of Missouri	379.8
5.	Melvin Hanson, University of Minnesota	376.7
6.	Russell Lyons, Iowa State College	369.9
7.	H. B. Hale, Texas A. & M. College	360.2
8.	Curtis Avery, Georgia State College	359.5
9.	D. L. Ator, Texas A. & M. College	355.8
10.	C. E. Friday, Mississippi State College	353.9

TEAMS

1.	Iowa State College	1093.9
2.	Texas A. & M. College	1057.9
3.	Mississippi State College	1048.0
4.	Oklahoma A. & M. College	1029.1
5.	University of Missouri	1028.6
6.	University of Minnesota	1004.6
7.	Kansas State College	992.6
8.	Georgia State College	992.3
9.	Pennsylvania State College	987.1
10.	University of Illinois	985.7

HOLSTEINS

INDIVIDUALS

1.	Jack Paulson, University of Nebraska	378.7
2.	D. L. Ator, Texas A. & M. College	374.6
3.	Thomas Duffy, University of Kentucky	366.3
4.	Austin Rheney, Georgia State College	363.7
5.	Harry Barnes, Georgia State College	362.1
6.	Ralph Porterfield, Ohio State University	358.5
7.	Max L. Dawdy, Kansas State College	356.4
8.	J. F. Cavanaugh, Kansas State College	353.4
9.	R. B. Dawson, Jr., Texas Technological College	353.2
10.	Bill Hartnell, University of Nebraska	352.2

TEAMS

1.	Georgia State College	1071.0
2.	University of Nebraska	1051.1
3.	Texas A. & M. College	1030.7
4.	University of Kentucky	1013.4
5.	Kansas State College	999.5
6.	Michigan State College (Tie)	978.1
7.	Ohio State University (Tie)	978.1
8.	Oklahoma A. & M. College	975.1
9.	University of Tennessee	963.4
10.	Iowa State College	958.0

JERSEYS

INDIVIDUALS

1.	Oscar Wesson, Purdue University	383.0
2.	Ralph Porterfield, Ohio State University	372.1
3.	Max L. Dawdy, Kansas State College	369.6
4.	Frank Smith, University of Missouri	360.4
5.	Lon McGilliard, Oklahoma A. & M. College	360.1
6.	Philip Lautenbach, Univeristy of Wisconsin	353.1
7.	Edwin Stauffacher, University of Wisconsin	352.7
8.	Harold Hansen, University of Nebraska	352.7
9.	C. H. Smith, New Jersey State College	352.1
10.	H. B. Hales, Texas A. & M. College	351.8

TEAMS

1.	Kansas State College	1052.9
2.	Ohio State University	1021.3
3.	University of Nebraska	1013.8
4.	Texas A. & M. College	1008.0
5.	Iowa State College	1001.8
6.	University of Tennessee	999.0
7.	Oklahoma A. &. M. College	994.1
8.	Mississippi State College	965.2
9.	Georgia State College	956.5
10.	University of Maryland	954.7

REPORT OF THE STUDENTS' NATIONAL CONTEST IN JUDGING DAIRY PRODUCTS

Toronto, Canada, October 20, 1941

The Ohio State University team was again victorious in the Dairy Products Judging Contest held at the Dairy Industries Exposition in Toronto in which 22 teams participated. Second and third places were won by teams from the University of Connecticut and Michigan State College, respectively. These three teams were awarded the Dairy Industrial Fellowships furnished by the Dairy Industries Supply Association.

First ranking teams and first ranking individuals also in the judging of butter, cheese, ice cream and milk were from Connecticut, Michigan, Connecticut and Ohio, respectively. The highest ranking individual in the entire contest was from Ohio State University.

Gold, silver and bronze medals were awarded to the individual contestants who won first, second and third places respectively in the judging of each of the four products as well as for all products.

The fellowships, cups and medals were provided by the Dairy Industries Supply Association which has sponsored the contest since 1930. The contest held this year was the 25th contest in the judging of dairy products sponsored wholly or in part by the American Dairy Science Association.

The 22 teams in the 1941 contest represented University of Connecticut, Cornell University, University of Illinois, Iowa State College, Kansas State College, University of Maryland, Massachusetts State College, Michigan State College, University of Minnesota, Mississippi State College, University of Nebraska, Ohio State University, Ontario Agricultural College, Pennsylvania State College, Purdue University, South Dakota State College, University of Tennessee, Texas A. & M. College, Texas Technological College, University of Vermont, Virginia Polytechnic Institute and University of Wisconsin.

Following is a list of those who won high standings in the contest:

ALL PRODUCTS

INDIVIDUALS

1.	John R. Kohl, Ohio State University	92.80
2.	Arnold C. Smith, University of Vermont	93.15
3.	Kenneth M. Dunn, Michigan State College	94.85
4.	Fred W. Carver, Ohio State University	96.90
5.	Saul M. Glick, Massachusetts State College	100.35
6.	Kurt Huber, South Dakota State College	100.80
7.	Leonard Goldberg, University of Connecticut	101.25
8.	Douglas Dana, University of Vermont	102.05
9.	Willim Rabinovitz, Massachusetts State College	102.50
10.	Richard Marland, University of Connecticut	103.45

TEAMS

1.	Ohio State University	13.00
2.	University of Connecticut	21.00
3.	Michigan State College	22.00
4.	Massachusetts State College	29.00
5.	University of Illinois	30.00
6.	University of Vermont	35.00
7.	Mississippi State College	37.00
8.	Cornell University	38.00
8.	Texas Technological College	38.00
10.	Iowa State College	39.00

BUTTER

INDIVIDUALS

1.	Leonard Goldberg, University of Connecticut	8.50
2.	Burns E. Woodward, University of Nebraska	9.50
3.	Mernice R. Volkers, Iowa State College	10.00
3.	Harry Nohren, University of Illinois	10.00
5.	Robert W. Bereiter, University of Wisconsin	10.50
5.	Arnold C. Smith, University of Vermont	10.50
7.	Howard O. Beach, Iowa State College	11.00
7.	Richard Marland, University of Connecticut	11.00
9.	Robert Crombie, University of Illinois	11.50
10.	Fred W. Carver, Ohio State University	12.00
10.	Dale W. Byers, Pennsylvania State College	12.00
10.	Norman R. Stoddard, University of Vermont	12.00
10.	Robert Edward Carr, University of Illinois	12.00
10.	Millard A. Gillham, Texas Technological College	12.00

TEAMS

1.	University of Connecticut	32.00
2.	University of Illinois	33.50
3.	University of Nebraska	37.00
4.	University of Minnesota	41.00
5.	Cornell University	41.50
6.	Pennsylvania State College	42.60
7.	Ohio State University	43.00
7.	Iowa State College	43.00
9.	South Dakota State College	44.00
10.	Texas Technological College	45.50
10.	University of Vermont	45.50

CHEESE

INDIVIDUALS

1.	Robert E. Stout, Michigan State College	25.50
2.	Clyde H. Stuntz, Iowa State College	27.00
3.	Fred W. Carver, Ohio State University	28.75
4.	Howard O. Beach, Iowa State College	29.75
5.	Kenneth M. Dunn, Michigan State College	30.00
5.	Arnold C. Smith, University of Vermont	30.00

5.	Richard Erickson, University of Minnesota	30.00
8.	Royal N. Gober, Mississippi State College	30.25
9.	Talwin Ruttum, South Dakota State College	30.75
10.	Glenn H. Whetzel, Purdue University	31.00
10.	Morris Van Daele, Kansas State College	31.00

TEAMS

1.	Michigan State College	87.50
2.	Ohio State University	93.00
3.	Mississippi State College	97.25
4.	University of Connecticut	98.50
4.	Iowa State College	98.50
6.	University of Wisconsin	100.50
7.	Massachusetts State College	101.00
8.	Cornell University	102.25
9.	South Dakota State College	103.50
10.	University of Illinois	103.75
10.	University of Minnesota	103.75

ICE CREAM

INDIVIDUALS

1.	Leonard Goldberg, University of Connecticut	29.50
2.	Kenneth M. Dunn, Michigan State College	29.75
3.	Henry Swain, Cornell University	30.25
4.	John R. Kohl, Ohio State University	30.75
5.	William Rabinovitz, Massachusetts State College	32.00
5.	Kurt Huber, South Dakota State College	32.00
5.	Saul M. Glick, Massachusetts State College	32.00
8.	Herman L. Neiditz, University of Connecticut	33.75
9.	Fred W. Carver, Ohio State University	35.25
10.	L. T. Simpson, Mississippi State College	35.75
10.	Arnold C. Smith, University of Vermont	35.75

TEAMS

1.	University of Connecticut	101.50
2.	Massachusetts State College	104.25
3.	Ohio State University	108.50
4.	Cornell University	113.00
5.	Michigan State College	116.75
6.	University of Maryland	119.00
7.	Purdue University	122.00
8.	University of Vermont	122.50
9.	Mississippi State College	128.50
10.	University of Illinois	132.00

MILK

INDIVIDUALS

1.	James R. Ebright, Ohio State University	15.00
2.	Clarence E. Kunz, Pennsylvania State College	16.15
3.	John R. Kohl, Ohio State University	16.55
4.	Arnold C. Smith, University of Vermont	16.90

5.	William Rabinovitz, Massachusetts State College	17.00
6.	Marion Smith, University of Tennessee	17.40
7.	Percy J. Smeltzer, Michigan State College	17.60
8.	Roy Lawson, University of Tennessee	18.10
8.	Roy Moffett, Texas Technological College	18.10
10.	Joe McGregor, Texas Technological College	18.55

TEAMS

1.	Ohio State University	52.45
2.	University of Vermont	59.50
3.	Texas Technological College	60.30
4.	Michigan State College	60.40
5.	Pennsylvania State College	61.10
6.	Massachusetts State College	62.05
7.	University of Tennessee	64.35
8.	University of Illinois	72.10
9.	Iowa State College	72.35
10.	Mississippi State College	74.80

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ABSTRACTS OF LITERATURE

ADVANCE ABSTRACTS OF REPORTS ACCEPTED FOR PUBLICATION IN THE JOURNAL OF DAIRY SCIENCE

870. Distribution of Diacetyl and Acetylmethylcarbinol between Fat and Water, with Special Reference to Butter. W. H. HOECKER AND B. W. HAMMER, Iowa State College.

In unsalted and salted butter, both the serum and the fat contained diacetyl and also acetylmethylcarbinol. The serum contained higher concentrations of the compounds than the fat, the differences being greater with acetylmethylcarbinol than with diacetyl. In each type of butter, a larger percentage of the total diacetyl than of the total acetylmethylcarbinol was contained in the fat. Butter into which a solution of diacetyl or a distillate of butter culture had been worked showed the same general distribution of diacetyl as butter made from cream containing butter culture.

In general, the data obtained on mixtures of Wesson oil and water or brine and mixtures of butterfat and water or brine agree with the results obtained on butter. In such mixtures, and also in butter although the results were not as definite as with the mixtures, the addition of sodium chloride increased the percentage of diacetyl or acetylmethylcarbinol that was in the fat. The concentration of diacetyl in the mixtures or in butter apparently did not affect the percentage contained in the fat, but as the concentration of acetylmethylcarbinol increased the percentage contained in the fat decreased.

871. Identification of the White Particles on Ripened Cheddar Cheese. F. L. DORN AND A. C. DAHLBERG, New York Agr. Expt. Sta., Geneva, N. Y.

A study was made of the white granular particles which commonly appear on the surface and throughout the body of cheddar cheese after 5–6 months ripening. The insolubility of the material in cold water, its low ash and calcium content, and a negative test for the lactate radical eliminated the possibility that the material was calcium lactate. The large amount of phosphorus present in the ash in relation to the calcium suggested a calcium phosphate salt as an impurity or a minor constituent of the white material.

The major constituent of the white particles was tyrosine, the identification of which was made on the basis of its characteristic color reactions, crystal formation, and by the melting point of the dibenzoyl derivative.

872. The Introduction of Cattle into Colonial North America. G. A. BOWLING, West Virginia University, Morgantown.

The initial period of importations of cattle into the North American Colonies extended from 1493 to about 1640.

During the period of discovery and colonization there were four possible paths of introduction of cattle into what is now the United States of America. (1) From the West Indies to any portion of the Atlantic and Gulf of Mexico coast line. (2) From Mexico into southwestern areas and California. (3) From the French colonies of the St. Lawrence Valley into the area of the "Old Northwest." (4) Directly from the colonizing European Nations to the American Colonies.

At an early date Spanish cattle were introduced in comparatively large numbers into the entire southern part of our country and they formed the foundation for the cattle breeding industry of that section. When the English, Dutch, Swedish and French colonies were founded in the east and the northeastern part of the continent, most of the cattle were imported directly from the colonizing European countries. After these colonies became established they, in turn, supplied cattle for the later colonies. After 1640 practically all of the American cattle trade, other than local transactions, was on an intercolonial basis, and the colonies as a group were self-sufficient in respect to cattle needs.

Since the initial introduction of cattle ended before the livestock improvement movement got under way in England and the other European countries the North American cattle population, numbering several millions at the end of the American Revolution, was of nondescript breeding. Real improvement of the cattle population of the United States did not begin until the second importation period which was not initiated until after the Revolutionary War.

873. Accuracy of Live Weights of Dairy Cows on Pasture. R. E. Hodgson and J. C. Knott, Bur. Dairy Indus., Washington, D. C.

The experimental error, the standard deviation of daily trends and the standard error of three-day initial and final live weights of cows on pasture have been determined by analyses of variance. The experimental error of 46 weight groups was 14.0 pounds with a range of from 7.0 to 28.3 pounds. The standard deviation of day to day trends of the groups of cows averaged 7.7 pounds with a range from 0.5 to 20.8 pounds. The standard error of the live weights of cows weighing about 1200 pounds averaged only 2.2 pounds. The experimental error, standard deviation of daily weight changes and standard error of the mean initial and final weights were of about the same order.

874. The Anatomy and Physiology of the Teat Sphincter. Dwight Espe and C. Y. Cannon, Iowa Agr. Expt. Sta., Ames, Iowa.

An abstract of this paper appears on page 500 of the June, 1941, issue of the Journal of Dairy Science.

BOOK REVIEW

875. The Market Milk Industry. CHESTER LINWOOD ROADHOUSE AND JAMES LLOYD HENDERSON, Univ. California. McGraw-Hill, New York, 624 pages.

This book of 624 pages published by McGraw-Hill Book Company of New York is a comprehensive treatise of the entire market milk industry. It is a book written in language that can be understood by the entire market milk industry. It is not too technical, yet it contains sufficient technical material to be of aid to the laboratory man who is attempting to get to the bottom of some plant problem.

The book will appeal to milk plant operators from the manager to the man on the milk wagon. It will appeal to the student in dairy departments, to milk inspectors and members of various boards of health.

There are twenty-five chapters in the book and some of the chapters include such subjects as history, composition and properties of milk, micro-organisms, enzymes, etc. An entire chapter is devoted to milk and public health, another to safeguarding milk supply and still another to sanitary production of market milk.

Construction and arrangement of dairy farm buildings as well as city milk plants are dealt with in separate chapters. Country receiving stations, transportation of milk, flavor of milk, milk plant operation, washing and sterilizing, and pasteurizing are covered in individual chapters.

Mechanical refrigeration is discussed briefly. Such subjects as creaming of milk, table cream and whipping cream and special milk products are covered in some detail.

Other chapters discuss distribution of milk (29 pages), cost of milk production, price and price plans, dairy inspection and control, milk in nutrition and the milk plant laboratory and its operation. The appendix contains dairy arithmetic problems, depreciation rates and other useful information.

The book is ably written and well illustrated with photographs, charts, tables and drawings. In all, there are 167 illustrations and 126 tables.

C.D.D.

BACTERIOLOGY

876. Control of Spreaders. M. O. ROBINSON, Alabama Polytechnic Inst., Auburn, Ala. Milk Dealer, *30*, No. 10: 32–33. July, 1941.

The author found that pouring media too deep in the plates caused trouble with spreaders. C.J.B.

877. Methods for the Bacteriological Examination of Milk Bottle Caps, Hoods and Closures. J. R. SANBORN AND ROBERT S. BREED, New

York State Exp. Sta., Geneva, N. Y. Jour. Milk Technol., *4*, No. 2: 63. 1941.

Methods for determining surface contamination of milk bottle caps or closure surfaces are given. The results of studies made show that the bacterial contamination of hood, and closure surfaces is normally very slight. Rinsing and contact culture methods used were found to be generally comparable. Results of over 100 analyses reveal a total absence of coliform organisms.

In view of many different sizes in closures and the low surface counts secured it is difficult to set a bacterial standard. It is suggested that the count be expressed in terms of colonies per unit of surface area. A figure stated was that closure surfaces coming in contact with the product should not have a count in excess of 2 colonies per square centimeter; or a count if not to exceed 10 or 25 colonies per cap or closure would seem reasonable. It was suggested, however, that at first a more lenient standard might be fixed until the problem had been given more study. L.H.B.

878. Effect of Pasteurization on Esch. Coli Organisms. C. PALEY AND M. L. ISAACS, Columbia Univ., New York, N. Y. Canad. Dairy and Ice Cream Jour., *20*, No. 7: 19. 1941.

This is a reprint of an article which appeared in the JOURNAL OF DAIRY SCIENCE, **24**: 421, 1941. O.F.G.

879. The Sporadic Appearance of Pin-Point Colonies in Raw Milk Counts. M. O. ROBINSON, Alabama Polytechnic Inst., Auburn, Ala. Milk Dealer, *30*, No. 9: 32, 44. June, 1941.

An account is given of a sporadic appearance of pinpoint colonies in raw milk counts due to placing a few pasteurized-milk cans through the washer while waiting for the producer cans. C.J.B.

BREEDING

880. Improving Dairy Herds to Lower Milk Production Cost. O. E. REED, U. S. D. A., Bureau of Dairy Industry, Washington, D. C. Canad. Dairy and Ice Cream Jour., *20*, No. 5: 26. 1941.

The problem of price reduction to the consumer is the joint concern of both the producer and the distributor. The job of the dairy industry is to help offset the low family incomes by adopting every efficient practice known. The breeding of better dairy cattle is one of the efficient practices. One-third of the heifers saved each year for herd replacements turn out to be poor producers. The real objective of the proved-sire system is not merely to raise the level of herd production but rather to "purify" the germ plasm to such an extent that fewer and fewer offspring will have low-

production inheritance. Production records are the heart of an efficient production system. Rapid developments in artificial insemination have opened up new opportunities in developing better herds. O.F.G.

881. (Hochschule für Bodenkultur, Vienna.) Rassenkundliche Untersuchungen an Schädelresten des altägyptischen Hausrindes. PIA D. J. JULIUS. Ztschr. f. Tierzücht. u. Züchtungsbiol., *48*, No. 1: 17–55. (14 figures and 9 tables of skull and horn measurements.) November, 1940.

The skulls investigated are from 3000 years, from 2500 years, and from 1000 years or less B.C. The skulls show prevailingly primigenius characteristics, the important deviations being tentatively imputed to the introduction of Mongolian blood. Among living races of cattle, the Hungarian steppe race most closely resembles these Egyptian cattle. J.L.L.

BUTTER

882. L'abaissement du taux des acides volatils ne rend pas le beurre "anormal." (Reduced Volatile Acid Values not Yielded by "Abnormal" Butter.) L. HOTON. Le Lait, *20*, Nos. 198, 199, 200: 497–510. 1940.

Maximum and minimum values of 33 and 26 were fixed in 1888 as being the limits for pure butter when it was subjected to the Reichert-Meissl determination. Butter having an R-M value below 26 was considered adulterated. These values were later questioned and several studies are reviewed indicating that butters of known purity sometimes yielded values outside the above limits and also showed a marked seasonal variation. Comparisons are presented between R-M values and indices of refraction. A negative correlation exists between these values but the relationship is not at all strict.

On a large number of samples analyzed at two week intervals from 1927 to 1938 the maximum R-M values were between 31.5–32.5 and the minimum values between 25.5–27.5, the former occurring during early spring and the latter about mid-autumn. The probable causes of some of these variations are discussed. O.R.I.

883. Mycostatic Salts Prevent Mold Growth on Stored Foods. W. L. MALLMAN, Mich. Agr. Expt. Sta., East Lansing, Mich. Food Indus., *13*, No. 7: 41–42, 54. 1941.

How to store foods at refrigerated temperatures for long periods without loss in quality or market value is a great problem to many food producers and distributors.

An essential for mold growth is the presence of moisture to germinate the spores and to start the mycelial growth. Such a condition exists when the humidity of storage room is sufficient to form a film of moisture on the surface of foods and their containers. When the humidity is controlled to prevent the formation of moisture, the foods lose moisture to the air. Shrinkage and loss of food quality result.

When moldy foods were examined it was found that penicillia type mold (green mold) dominated. It was also found that enough mold to cause trouble was brought into the storage room on the food themselves.

It was found that mold spoilage could be controlled by concurrent disinfection. This may be accomplished in several ways. Carbon dioxide and small amounts of ozone are two ways of doing this at reasonable price. Introduction of a chemical agent, sodium pentachlorophenate, into the packing materials is a method which has proved effective for foods stored for three to six months. J.C.M.

884. How to Improve the Keeping Quality of Butter. O. F. HUNZIKER, La Grange, Ill. Canad. Dairy and Ice Cream Jour., *20*, No. 7: 23. 1941.

Good butter is made from high quality cream. The cardinal essentials for high quality in cream are sanitation, low temperatures and freshness, all of which start on the farm and must be practiced until the final product reaches the consumer. Efficient pasteurization accompanied by a sanitary status as to equipment, plant and all operations, that will protect the cream between pasteurizer and churn, and the butter between churn and consumer package, from every potential channel of recontamination are essential. Chemical deterioration which results in fishy, tallowy, metallic and storage flavors is generally hastened and intensified by the presence of salt, high acidity and metallic compounds. Unsalted butter is more stable chemically but is highly perishable bacteriologically. O.F.G.

885. Leakiness in Butter. S. T. COULTER, Univ. Minnesota, St. Paul, Minn. Canad. Dairy and Ice Cream Jour., *20*, No. 7: 66. 1941.

The appearance of a plug of butter drawn with a trier is not a reliable index to whether or not the butter will lose moisture during and after printing. The Coulter and Combs method, described in this article, has been found most useful. Among the factors which influence the water retaining properties of butter are: (1) Composition of the butterfat—winter butter retains more water than summer butter, and (2) Methods of manufacture. The factors involved under methods of manufacture are (a) thoroughness of cream cooling, (b) temperature of the butter during working, (c) stage of working at which water for standardization is added, (d) salting at the

granular stage or after the butter has been worked into a roll, (e) amount of working, and (f) composition of the butter. O.F.G.

886. The Value of Mold and Yeast Control Work. E. G. Hood, Dept. Agr., Ottawa, Canad. Canad. Dairy and Ice Cream Jour., *20*, No. 4: 29. 1941.

The main sources of molds and yeasts in butter are: (1) Inefficient pasteurization and raw cream recontamination. (2) Dead ends in pipes. (3) Improperly cleaned and sterilized vat, pumps and pipes. (4) Improperly cleaned and sterilized churns. (5) Impure water, unclean holding tanks and ice. (6) Improperly treated parchment linings. (7) Butter boxes—unseasoned lumber and damp storage.

The Storch test is not sufficient evidence for satisfactory pasteurization of cream and needs to be supplemented by yeast and mold counts. Pasteurized butter should contain less than a total of 50 molds and yeasts and 25,000 bacteria per gram of butter where starters are not used. The mold and yeast count has been found to be an index of keeping quality of the butter. O.F.G.

887. A Summary of Recent New Zealand Research Work on Buttermaking. Anonymous. Canad. Dairy and Ice Cream Jour., *20*, No. 4: 64. 1941.

Fat losses in churning—Results from estimating fat losses by weighing and analyzing the cream, buttermilk and wash water agreed well with the methods used by Udy and by Bird and Derby.

Fat oxidation—Butters made from ripened cream oxidized more rapidly than corresponding butters made from cream acidified to the same extent with pure lactic acid. Salted butters oxidized more rapidly than corresponding unsalted butters. Low pasteurization temperatures favored oxidation. The presence of an oxidizing enzyme was indicated.

Butter starters—Starters are not used in New Zealand for "ripening" cream but a small amount is used by some factories to give a better flavor to butter made from sweet cream. *Str. cremoris* is used to give a good flavor.

Hardness of butter—The Blair instrument has given useful indications of butter hardness although it is not without criticism.

Rate of cooling cream—The more rapidly cream is cooled after pasteurization the harder is the butter. Seasonal and even daily variations were greater than variations produced by different methods of treatment.

Antioxidants—Vitamins C and E appeared to have antioxygenic effects. Soluble phosphates and citrates of the milk plasma gave striking positive results. O.F.G.

888. Research and the Creamery Industry. H. MACY, Univ. Minnesota, St. Paul, Minn. Canad. Dairy and Ice Cream Jour., *20*, No. 5: 66. 1941.

This article is an account of the scientific practices which have been used to improve the quality of creamery butter. The use of the propionates in retarding or preventing the growth of surface molds on printed butter is an example of these practices. The use of carbon dioxide has not proved successful in storing butter. The putrid or cheesy surface taint has frequently been traced to water supplies. Some waters have required so much chlorine to destroy the causative organisms that a chemical flavor has been imparted to the butter and made it unsaleable. Experiments with cereal antioxidants at Minnesota have not proved particularly successful. The mold mycelia count is practically an infallible test to determine whether or not butter has been made from a cream of poor quality. A test has been developed for use in the creamery receiving room to detect molds. O.F.G.

889. Water, Churn Sanitation and Butter Flavor. M. C. JAMIESON, Univ. Manitoba, Winnipeg, Man. Canad. Dairy and Ice Cream Jour., *20*, No. 6: 20. 1941.

Seventy-one per cent of bacteria whose colonies fluoresced under ultraviolet light produced butter with flavor scores under 37. Over 70 per cent of oxidase-positive bacteria were responsible for flavor scores of 37 or lower. Out of 65 cultures classed as probable surface taint producing type 56.9 per cent were definitely so; 43.1 per cent caused a cheesy to rancid flavor, while 15.4 per cent produced an unclean taste. Poor sanitation in a churn can off-set the best water supply and lower flavor scores in butter. Skill in manufacture can overcome some defects in either water or sanitation. The majority of fluorescent and oxidase-positive bacteria are more deleterious to butter flavor than types otherwise distinguishable from these in colony growth. O.F.G.

890. The Significance of Yeast and Mold Counts. A. G. LEGGATT, Ontario Agr. College, Guelph, Ont. Canad. Dairy and Ice Cream Jour., *20*, No. 6: 23. 1941.

The yeast and mold count of butter is a measure of the creamery sanitation. The test is dependent upon taking the samples as follows: (1) Take sample from butter that has been worked, (2) Make up sample with as many small pieces and from as many locations in the mass of butter as is possible, (3) Take the sample quickly, (4) Replace the cover of the sample jar immediately, (5) Do not allow the hand or any part of the clothing to pass over the mouth of the jar while open, and (6) Always hold the cover of the jar topside up. Where a creamery runs high with its yeast and mold counts a

line check should be made. A line check consists of a series of samples taken from the same batch of cream so as to follow it through the various processes until it is manufactured into butter. The churn is the chief source of contamination. O.F.G.

891. Observations on the Use of the "Vacreator." H. W. NICHOL, Saskatchewan Co-operative Creameries, Ltd., Regina, Sask. Canad. Dairy and Ice Cream Jour., *20*, No. 6: 64. 1941.

Number 1 butter can be made from cream with feed and volatile weed flavors by pasteurizing the cream in the "vacreator." Cream with yeasty, cheesy, metallic or stale flavors cannot be made into No. 1 butter by "vacreating" although the flavor of this butter will be greatly improved. Warning is issued, therefore, against becoming lenient on the grading of cream for buttermarking purposes. The "vacreator" has done an excellent job in preserving the natural flavors of butter and has greatly improved the keeping quality. Surface flavor on butter has been almost entirely eliminated. The body and texture of the butter are improved. The use of the "vacreator" resulted in a reasonable saving in water and a definite saving in power and fuel. O.F.G.

CHEESE

892. Controlling Mold Growth on Cheddar Cheese. C. K. JOHNS, Central Experimental Farm, Ottawa, Can. Canad. Dairy and Ice Cream Jour., *20*, No. 4: 36. 1941.

Cheddar cheese swabbed with 4 per cent and 8 per cent solutions of calcium propionate showed slight molding but their condition was vastly superior to that of the control cheese. The cheese treated with 12 per cent solution remained free from mold growth. Calcium propionate does not kill molds—it merely checks their growth. Dipping of the cheese in solution probably gives more efficient application but has certain disadvantages which do not make for simplicity. O.F.G.

893. Curing and Merchandising Cheese in Sealed Packs. H. L. WILSON, Bureau of Dairy Industry, U. S. D. A., Washington, D. C. Canad. Dairy and Ice Cream Jour., *20*, No. 7: 28. 1941.

The greatest difficulty in curing cheese in sealed containers is the uncertainty of the quality of the curd when packed. Results show that when the methylene blue reduction time of the milk is less than 3 hours a high percentage of undergrade cheese is made. Only a small percentage of milk received at cheese factories during summer months meets this requirement. Pasteurization of milk results in a better and more uniform cheese, especially if the milk does not meet the minimum reduction time of 3 hours. The con-

trol of acidity is the greatest quality controlling factor. Directions are given for making a cheese having a smooth, fine and waxy body, a texture free from mechanical and other openings, and a pleasant characteristic nutty flavor. O.F.G.

894. Salt for Cheesemaking. L. B. BRYANT, Ontario Agr. College, Guelph, Ont. Canad. Dairy and Ice Cream Jour., *20*, No. 4: 21. 1941.

Cheese salt should be clean, of a high grade of purity, coarse-grained, flaky and free from lumps because it dissolves more easily. Thirty-four samples of cheese salt were subjected to physical, chemical, bacteriological and cheese manufacturing tests. Twenty-two of these salts were not sufficiently coarse for cheesemaking. Bacteria counts ranged from 0 to 42,000 per gram of salt, molds ranged from 2 to 40 per gram, but no yeasts were found. Many of the samples contained considerable amounts of foreign material. In manufacturing tests, the rate of solubility and draining off whey in the salting operation were both more rapid in the case of fine salts. Cheese to which the coarse salt was added showed the greatest loss of salt and the smallest loss of protein and fat in the wheys draining off from the salting vats and press, but these losses were not large enough to cause a significant difference in the composition of the final cheese. The scores on cheese made from fine or coarse salt were not appreciably different. O.F.G.

895. Meeting the Demand for Imported Type Cheese. O. R. IRVINE, Ontario Agricultural College, Guelph, Ont. Canad. Dairy and Ice Cream Jour., *20*, No. 4: 80. 1941.

Dislocation of the international cheese trade has affected Canadian imports of the following types: Roquefort, Danish blue, Gorgonzola, Gruyiere, Emmenthaler, Gouda, Edam, Parmesan, Camembert and Brie. This situation has created a market for Canadian cheesemakers. The chance to introduce Canadian made replicas of these imported cheese is dependent upon technical difficulties which must be overcome. The possibilities of making Cheshire, Edam and Gouda, and the blue types of cheese in Canada seem promising. O.F.G.

896. A Review of the Ontario Cheese Industry. H. B. SANDWITH, Chief Cheese Instructor for Eastern Ontario. Canad. Dairy and Ice Cream Jour., *20*, No. 5: 23. 1941.

Factors which have tended to improve the cheese industry in Canada during the past season are: (1) The Cheese and Cheese Factory Improvement Act and subsidies, (2) Greater co-operation between producer and cheesemaker, (3) The change in instructional work, (4) Favorable weather

conditions, and (5) General improvement in cheese factories under license system. Under the Cheese Act the standard of the cheesemaker has been raised. The total number of undergrades of cheese, due to mechanical defects, has been reduced. Flavor defects have appeared less frequently.

O.F.G.

897. Factors Affecting the Quality of Cheese. S. L. TUCKEY, Univ. Illinois, Urbana, Ill. Canad. Dairy and Ice Cream Jour., *20*, No. 6: 30. 1941.

Flavor in cheddar cheese is the result of (1) bacterial development, (2) acidity development, (3) moisture content, and (4) salt content. Under conditions of too much acid, bitter flavor defects predominate but this flavor also may occur under other conditions. In studies at the University of Illinois cheese made with a salt content of 1.7 per cent was never criticized as being bitter. It was also noted that this cheese was slower in breakdown of body than cheese with a salt content of 1.2 per cent. Cheese that is to be aged for 6 to 12 months probably should have more salt than cheese which is to be sold on the market fresh with a mild flavor. Butterfat contributes to the characteristic flavor of cheese but the use of a portion of homogenized raw or a mixture of enzymes to accelerate the splitting of fatty acids has resulted in the development in the cheese in a short time of too much rancidity. O.F.G.

898. Bacterial Cultures for Cheese Made from Pasteurized Milk. W. C. HARRIS, B. W. HAMMER AND C. E. LANE, Iowa State College, Ames, Iowa. Canad. Dairy and Ice Cream Jour., *20*, No. 6: 70. 1941.

Thirty-four cultures of micrococci isolated from cheddar cheese where studied. They were grouped into 23 species 12 of which could be identified. Cheese was made from milk cultured with these 23 species. On examination of the cheese it was found that they could be divided into 3 groups according to flavor: (1) those having an undesirable effect, (2) those having no definite effect, and (3) those having a desirable effect. Thirteen of the cultures appeared to improve the flavor of the cheese. The results suggested that certain strains of micrococci may be useful in making cheese from pasteurized milk but selection of the culture should be made on the basis of strain rather than species. The results also indicated that certain strains of propionic acid bacteria may be useful in the manufacture of cheddar cheese from pasteurized milk. O.F.G.

CHEMISTRY

899. Methods of Determining Vitamin B in Foods. EARL D. STEWART, Consumer's Yeast, Oakland, Calif. Food Indus., *13*, No. 7: 56–61. 1941.

This article deals with the determination of vitamin B_1 in bread and

bakery goods but the factors to be kept in mind will be much the same for any food product.

The author goes into very lengthy discussions on the different ways that have been derived to test for vitamin B_1.

None of these methods are very desirable as to general applicability or reliability as yet. With increased activity in this field better methods are certain to come. J.C.M.

CONCENTRATED AND DRY MILK; BY-PRODUCTS

900. The Development of New Methods in Dairy Science. P. F. SHARP, Cornell Univ., Ithaca, N. Y. Canad. Dairy and Ice Cream Jour., *20*, No. 4: 24. 1941.

The author discusses the new developments and newer knowledge of the processing, distribution and nutritive value of milk. Examples of recent research findings are illustrated by discussing some of the products and by-products of milk such as frozen cream, dried whey, casein, etc. He feels that opportunities for research in the field of dairy products are almost infinite. O.F.G.

901. The Whey Problem. J. G. DAVIS, Natl. Inst. for Res. in Dairying, Shinfield, nr. Reading, Eng. Canad. Dairy and Ice Cream Jour., *20*, No. 6: 72. 1941.

The whey problem arose with the advent of factory cheese making. Whey has been used in its unchanged form for hog feeding, for whey silage and for conversion to whey beverages. It has been dried in the form of whey paste, whey powder and for extraction of lactose. It has been boiled to form albumen cheese. It has been microbiologically utilized by fermentation to lactic acid, fermentation to alcohol and as a medium for yeast for cattle food. It is particularly rich in calcium and vitamin B_2 (vitamin G or riboflavin) as well as lactose and is, therefore, a valuable source of human nutrients. There is need for further developments of methods of utilizing whey. O.F.G.

902. L'utilisation du sérum. (The Utilization of Whey.) G. GENIN. Le Lait, *20*, Nos. 198, 199, 200: 510–517. 1940.

This is a description of the process developed by Sheffield Farms for the extraction and purification of lactose and precipitation of albumin. O.R.I.

FOOD VALUE OF DAIRY PRODUCTS

903. Some Trends in Consumption of Dairy Products. E. E. VIAL, Bur. Agr. Economics, U.S.D.A. Milk Dealer, *30*, No. 9: 118–123. June, 1941.

A discussion is included of the trend in the consumption of dairy prod-

uets. Data are presented showing the *per capita* consumption of dairy products; changes in consumption of milk in selected Northeastern markets, 1936–40; relation between income and consumer purchases of dairy products, and the relation between income and consumer purchases, in pounds, of fruits, vegetables, meats, dairy products, and eggs.

The effect of the defense program on the consumption of dairy products is also discussed. The author concludes that it seems quite probable that during the next year or two our total consumption of dairy products will increase. C.J.B.

904. Better Meals for Tomorrow. LEWIS W. WATERS, General Foods Corp., New York City. Jour. Milk Technol., *4*, No. 2: 68. 1941.

A suggested program for the food industry is given which should assure better meals for tomorrow. The program is as follows: 1. Use the best materials. 2. Manufacture efficiently. 3. Process carefully. 4. Package properly. 5. Distribute widely. 6. Advertise honestly. 7. Price wisely. 8. Supply directions. 9. Strive for convenience. 10. Maintain constant research. L.H.B.

905. Le lait frais pasteurisé irradié a l' abri de l'air et la vitamine D indications medicales—posologie. (Fresh Milk Pasteurized and Irradiated Protected from Air; the Medical Requirements and Dosage of Vitamin D.) JEAN VIEILLY. Le Lait, *20*, Nos. 198, 199, 200: 517–527. 1940.

Literature is reviewed and many opinions cited (although no bibliography is included) on methods of providing increased supplies of vitamin D particularly by the irradiation process. Some of the symptoms of hypo- and hyper-vitaminosis D and hypercalcemia are discussed especially in relation to therapy by irradiated egosterol.

It is pointed out that the irradiation process as applied to milk takes place rapidly with no possibility for toxic products to be developed. The process should be limited to milk. Fresh, pasteurized, irradiated milk is an excellent source of this vitamin for expectant mothers and infants. O.R.I.

906. How to Add Vitamin D Concentrate and Control Vitamin D in Milk. C. I. POST, Natl. Oil Products Co., Harrison, N. J. Food Indus., *13*, No. 6: 41–43. 1941.

This subject falls into three phases: (1) Control of the vitamin D potency of the concentrate; (2) Control of the physical addition of the concentrate to the milk and (3) Control of the potency of the finished vitamin D milk.

The manufacturer of the concentrate must make certain that the potency of the concentrate which he sells to the milk industry is as claimed on the label, plus a reasonable safety factor.

Vitamin D concentrate should be supplied to the milk plant in sterile cans. Proper handling of these cans and the addition of the contents to the milk is of extreme importance, and if properly done the correct potency of the resulting vitamin D milk is automatically achieved.

If the first two steps are properly carried out the milk distributor need not worry about phase No. 3. J.C.M.

907. **Irradiation and Control of Vitamin D in Milk.** K. G. WECKEL, Univ. Wisconsin, Madison, Wis. Food Indus., *13*, No. 6: 43–46. 1941.

The amount of vitamin D occurring naturally in milk is between 20 and 30 U.S.P. units per quart. Optimum potency desired is estimated to be between 135–400 units per quart. Therefore, the increase desired in an irradiated milk product is between 6 and 16 times the natural content.

The process of irradiating milk consists in exposing milk in thin films to radiation of wave lengths of from 2300 to 3100 Angstrom units. Several factors affect the response of milk to radiation; they are: (1) Characteristics of the film; (2) Characteristics of radiation; (3) Concentration of activatable substances and opacity of the milk to radiation; (4) Mechanical principles.

The method of creating the films in commercial installations consists of flowing milk by gravity over vertical, smooth, plane or cylindrical surfaces. The flow capacity of the film normally used ranges from 35 to 1,000 lbs. per linear foot per hour.

Radiation is derived from one of two sources: (1) the carbon electrode arc, or (2) the quartz mercury-vapor arc. With both types of arcs the power supply must be kept at a constant to insure proper radiation.

Normally, the variations in the fat content do not affect measurably the response of milk to radiation. It has been shown that significant increase in fat content of milk results in an increase (not proportionate) of the vitamin D content of the milk.

A number of modified milk products may be irradiated (*i.e.*, cream, evaporated milk, milk powder, and ice cream mix).

It is technically possible to irradiate fluid whole milk at almost any stage from the time of its production until filled into the bottle. Usually milk is irradiated just prior to its pasteurization. Evaporated milk is usually irradiated while hot when drawn from the vacuum pan and prior to storage.

The vitamin D of natural or fortified milk products is quite stable. It is stable at ordinary pasteurization temperature of 62.8° C. for 30 minutes or sterilization at 115.6° C. for 15 minutes. The form vitamin D_2 has been reported unstable at higher temperatures such as 232° to 260° C. for five minutes.

Two significant developments have resulted from research in the process of irradiation of milk during the past eight years. These are the increase in

flow capacities of commercial milk irradiators from 4,000 to 15,000 lbs. of milk per hour, and the increase of potency from 135 to 400 U.S.P. units per quart. J.C.M.

908. How to Add and Control Vitamin A in Margarine. H. W. VAHLTEICH, The Best Foods, Inc., Bayonne, N. J. Food Indus., *13*, No. 6: 39–41. 1941.

The adding of vitamin A to margarine is a task which demands close contact between the laboratory and the purchaser. In the case of vitamin A the U.S.P. XI bio-assay method is the only one official in this country, but one cannot rely on it alone because it is too time consuming.

There must, therefore, be available more rapid and reliable day-to-day control tests. For this the Carr-Price quantitative test is used with the aid of a spectrophotometer. The control procedure is essentially as follows: (1) Determining of vitamin A potency of the vitamin A enriching oil to be used in margarine by the U.S.P. XI bio-assay technique. (2) Checking the vitamin A potency of the enriching oil with the quartz spectrophotometer based on the U.S.P. XI Standard of Reference Cod Liver Oil. (3) Determination of the presence of vitamin A in the margarine oil by the Carr-Price test. (4) Determination of the presence of vitamin A in the margarine oil by the quartz spectrophotometer. (5) Having the finished product checked by independent laboratories thoroughly familiar with the U.S.P. XI bio-testing procedure. J.C.M.

909. Defining Quantity Control. ANONYMOUS. Food Indus., *13*, No. 6: 37. 1941.

There are many in the food industry who see in the vitamin-enrichment program nothing more than an opportunity to sell more foods.

Quantity control does not, as many believe, imply making the best possible product, or putting in the most vitamins. The quantity level may be whatever management or government regulations define. In controlling quantity, the problem is to keep it uniform at whatever level of quantity has been selected.

Quantity control means the procedure of producing uniformity of quality by whatever means it may be necessary to employ. J.C.M.

910. How to Get Vitamin D into Milk by Feeding Cows Yeast. CHARLES N. FREY, Fleischmann Lab., Standard Brands, Inc., New York, N. Y. Food Indus., *13*, No. 6: 46–48. 1941.

Vitamin D was identified as a definite entity in 1922, the production of vitamin D by irradiation was established in 1924. The irradiation of yeast was begun on a commercial scale in 1928. The first yeast produced commer-

cially had a potency of 810 U.S.P. units. Today yeasts containing 7,200 U.S.P. units per gram are on the market.

Scientific investigations have shown that the production of so-called "metabolized vitamin D milk" of standard potency depends on three rules: (1) The amount of irradiated yeast to be fed depends upon the milk production of the cow; (2) The high producers are more efficient than the low producers in transferring vitamin D from the ration to the milk; (3) The yeast must be fed two or more times daily rather than at one feeding.

The milk reaches its maximum vitamin D potency after two to three weeks of yeast feeding. After the maximum is reached the potency will not change.

This article also tells how the potency of vitamin D is determined.

J.C.M.

911. **Conference Sets Course to Better National Nutrition.** GEORGE E. DOYLING, JR., Food Indus., Washington, D. C. Food Indus., *13*, No. 7: 64–66. 1941.

On May 26–28 the National Defense Nutrition Conference held a meeting in Washington, D. C. Some of the topics discussed were as follows:

Recommended diets were set up with special stress on the fact that cheaper foods, such as inexpensive meat cuts and oleomargarine, are just as satisfying from the nutrition standpoint as the more expensive foods.

Fortification, restoration, and enrichment should be practiced only when absolutely necessary. Flour and bread are perfect examples where enrichment is necessary.

Above all others one point was stressed—education. All sides agreed that the front-line job is "slugging away," constantly using all the facilities for reaching public opinion that are available. J.C.M.

912. **How the American Soldier Is Fed.** COL. PAUL P. LOGAN, Office of the Quartermaster General, Washington, D. C. Milk Dealer, *30*, No. 9: 98–101. June, 1941.

The standard "garrison" ration is used in peacetime and under ordinary conditions for feeding soldiers in camps. This ration specifies (among other things) one ounce of evaporated milk, two ounces of butter, and one-quarter ounce cheese. The specified quantities are used only as a guide, and wide discretion is allowed to the post quartermaster and mess sergeant in actual purchase of food and serving of meals. The standard ration is not actually issued in kind. It is used as a monetary basis for the supply of subsistence or food.

Methods of purchasing, field rations, and the securing of fluid milk are discussed. C.J.B.

ICE CREAM

913. Report of Committee on Sanitary Control of Ice Cream. F. W. FABIAN, Michigan State College, East Lansing, Mich. Jour. Milk Technol., *4*, No. 2: 100. 1941.

Progress in the field of ice cream and frozen desserts is reported.

The report covers points relative to ice cream sanitation as experienced in several sections of the United States and Canada.

Regulation governing counter freezer installations and packaging ice cream receives considerable attention.

A good digest of Canada's legislation affecting packaging and selling of ice cream is given. L.H.B.

914. The Use of Corn Sugar Solids in Ice Cream and Ices. L. R. GLAZIER AND M. J. MACK, Massachusetts State College, Amherst, Mass. Canad. Dairy and Ice Cream Jour., *20*, No. 5: 42. 1941.

A majority of consumers could discern no decrease in sweetness in ice cream when 25 per cent of the sucrose was replaced with corn syrup solids. There was a noticeable improvement in body and texture when this substitution took place. The use of corn syrup solids had little effect on titratable acidity and protein stability, raised the freezing point slightly, increased the mix viscosity about 10 per cent and had little effect on whipping ability. The development of sandiness on prolonged storage was delayed by the use of corn syrup solids. O.F.G.

915. Concentrating by Freezing to Protect Flavor. ANONYMOUS. Food Indus., *13*, No. 4: 50. 1941.

To concentrate a solution, the solvent must be made to change its physical state so that it may be removed. One way is to convert it into a vapor by raising its temperature. In so doing the high temperature often injures the flavor of the liquid, or sometimes the flavor boils off also.

If reduced temperatures are used, the solvent can be partially frozen and removed from the solution by mechanical means. This principle depends on the fact that slow freezing of a solution (not entectic mixture) will result in separation of crystals of the pure solvent.

Wilpert A. Heyman developed a machine of continuous concentration by continuous freezing. After a demonstration it produced a concentrate of about 50 per cent of its original volume by one passage through the cycle.

The apparatus consists of an inclined jacketed tube in which a helical worm rotates. Brine at $-10°$ to $-15°$ F. is fed into the jacket. Juice to be concentrated enters the space between worm and jacket, and as it moves it is frozen very slowly into a slush at 25° F. This slush is put into a perforated basket centrifugal. The concentrate is spun off leaving a white, tasteless water ice amounting to 50 per cent of the input juice.

A second passage will increase the total removal to 65 per cent or even higher.

In essence, this method of concentration depends on slow freezing as contrasted to quick freezing. Judging by the results of this demonstration it appears that continuous freezing for concentration must be done very slowly.

J.C.M.

916. Corn Sirup Solids Improve Frozen Dairy Products. LYNN R. GLAZIER AND MERRILL J. MACK, State College, Amherst, Mass. Food Indus., *13*, No. 16: 68–70. 1941.

Added sweetening agents make up a large percentage of the food solids of frozen dairy products. They comprise about 40 per cent of the solids of ice cream.

Corn sirup solids result from the dehydration of corn sirup to a stable, white product. The carbohydrates presented in corn sirup solids are dextrose, maltose and dextrins.

The two principle objectives of this investigation were to determine the effect of corn sirup solids on flavor, body and texture of frozen desserts, and determine relative sweetening value of the common corn sweeteners when used in ice cream.

It was found that the viscosity of the ice cream mix increased about 10 per cent when corn sirup solids replaced 33⅓ per cent of the sucrose.

An analysis of the consumer judgment leads to the conclusion that the replacement of 20 to 26 per cent of the sucrose improves the flavor, body and texture of ice cream, with no significant change in sweetness.

J.C.M.

917. How to Make Naturally Flavored Maraschino-type Cherries. F. A. LEE, N. Y. Agr. Expt. Sta., Geneva, N. Y. and E. A. BEAVENS, U. S. Dept. Agr., Geneva, N. Y. Food Indus., *13*, No. 7: 52–54. 1941.

Cherries as gathered from the orchard cannot be processed into the colored product and still retain their natural color and flavor.

In these experiments Napoleon (Royal Ann) cherries were used throughout. In preparing naturally flavored cherries having the required firmness and color it was necessary to bleach and dye the fruit in the usual manner.

This article goes into detail telling how the sirup from Montmorency and English Morello cherries was extracted and added in different combinations to the bleached and dyed cherries to produce the best natural flavor.

J.C.M.

918. Flash Sterilization Kills Spoilage Spores. D. J. WESSEL AND H. A. BENJAMIN, American Can Co., Maywood, Ill. Food Indus., *13*, No. 8: 40–43. 1941.

In the past years tomato juice canners have reported a certain amount

of spoilage, by microorganisms possessing resistance to destruction by heat.

This article tells of the trouble encountered in trying to kill these microorganisms without spoiling the flavor and general qualities of the juice.

The following process was found to kill the organisms and have no bad effect on the flavor. (1) Rapidly heat to 252° F. (96 seconds). (2) Rapidly cool to 190° F. and put into cans. (3) Put filled cans in boiling water for 16 minutes.

With the above procedure extreme care must be taken so that the juice will not become re-infected after the "flash" heating.

The problem presents suggestions to aid in handling dairy foods when spoilage organisms of this type present themselves. J.C.M.

Note: These organisms originating in the soil are not affected by temperatures commonly employed in heat-treating milk and dairy foods.

919. Salaries, Seasons and Ice Cream Sales. ANONYMOUS. Food Indus., *13*, No. 8: 54, 91. 1941.

Consumption of principal manufactured dairy products has steadily increased since 1930. The trend in ice cream has been upward but not steady. In 1933 ice cream purchases were only two-thirds of 1924–29 annual sales.

The reason for this fluctuation in sales is caused by variations in the purchasing power of the urban population. Likewise, the individual consumption varies with the income level.

Regular temperature fluctuations, occurring during the year, naturally cause seasonal changes in ice cream consumption. No authentic data are available on these variations.

Ice cream production has become more uniform throughout the year. Probably education, promotion, and advertising had a great deal to do with the increase in winter months. The item of ice cream as a food has also been a factor in this development. J.C.M.

920. Ice Cream Manufacture in 1941. L. J. HYNES. Food Mfr., *13*, No. 3: 60–61. 1941.

Ice cream is composed of substances which will be the first to be rationed when rationing starts, because it is regarded more or less of a "luxury."

There is an order prohibiting the use of liquid full-cream milk or skimmilk in ice cream. It has not affected the manufacturers very seriously, because most of them use milk solids for their mix.

The milk powders are also becoming limited. This article suggests such substitutes as unsalted margarine, and vegetable oils for butterfat; corn starch, and soya-bean flour for milk solids not fat, and honey for sweetening. J.C.M.

921. English Fruit Juices as Source of Vitamin C. VERNON L. CHARLEY, Long Ashton, Bristol, England. Food Mfr., *16*, No. 5: 102, 103. 1941.

The past six years have seen a steady development in the English fruit juice industry. The University of Bristol Research Station is making a study of fruit juices with regard to vitamin content. They tested the juices fresh and then after being canned from one to two years.

In apple juice it was found that canning reduced the already small vitamin content to practically nil. Strawberry juice for ice cream and other purposes decreases in vitamin content and flavor on storage and therefore is not satisfactory. Black currant juice can be sweetened and stored without serious losses of vitamin content. J.C.M.

922. Selection and Use of Color in Ice Cream. C. A. IVERSON, Iowa State College, Ames, Iowa. Canad. Dairy and Ice Cream Jour., *20*, No. 7: 25. 1941.

Desirable color increases the anticipated pleasure in eating food. The shade and intensity of color should harmonize with the product to be sold. Color should be uniform and free from flavor defects. A coloring material which changes its shade or intensity with varying acidity is undesirable. Highly colored ice creams are meeting with less and less favor by the consuming public. The author is not enthusiastic about vitamin fortification of ice cream in general but feels that the use of carotene concentrates may have merit. The cost of color purchased in dry form is lowest but keeping quality is usually best in paste form. A disadvantage in the purchase of liquid colors is the danger of considerable bacterial contamination. Boiling hot water added to the dry color to make the solution will give a liquid color which will keep for 2 weeks without danger of serious contamination. O.F.G.

923. Some Observations of the Vanilla Market. R. SCHLOTTERER, Secretary, Vanilla Bean Assoc. Canad. Dairy and Ice Cream Jour., *20*, No. 7: 62. 1941.

Importation of vanilla beans has been drastically curtailed because of the European conflict. A continuance of the blockade of Madagascar will cause a lengthening of the vanilla famine since about 60 per cent of our beans have come from this and neighboring islands. It is estimated that the importation for 1941 will be about 20 per cent below average. Sources of supplies closer to our shores are Mexico, Tahiti and the West Indies. The quality of the Mexican crop is below par due to early picking of immature beans. Reliable reports about the 1942 Mexican crop are not encouraging. It is expected that about 200,000 pounds of Tahiti beans will be imported in 1941. Vanilla prices will continue to be high. O.F.G.

924. A Study of Chocolate Coatings for Ice Cream Bars. J. H. ERB, Ohio State Univ., Columbus, O. Canad. Dairy and Ice Cream Jour., *20*, No. 4: 68. 1941.

"Free fat" in the chocolate is responsible for the fluidity of the mass when heated to a temperature above the melting point of the fat. Other portions of the chocolate reduce the fluidity unless coated with a layer of fat. Factors which affect the coverage of chocolate are: (1) Composition of the coating, (2) Fineness of grinding, (3) Heat treatment when melting, (4) Temperature of the coating as well as the ice cream, when dipping, (5) Amount of moisture incorporated into the melted chocolate at the dipping tank, and (6) The use of lecithin. Lecithin retards thickening caused by excess moisture incorporation, by lowering the interfacial tension of the fat. The "bob" test can be used to determine very accurately the coverage properties of a coating. O.F.G.

925. Selecting, Preparing and Using Flavors for Ice Cream. E. G. WEED, Jackson, Mich. Canad. Dairy and Ice Cream Jour., *20*, No. 5: 58. 1941.

The most common causes of bad flavors in ice cream mixes are: (1) Sour, old or bitter cream, (2) Cream with oily, metallic, weedy or burnt taste, (3) Inferior quality condensed milk, (4) Inferior gum or gelatin, (5) Inferior fruits or nuts, and (6) Too much or not enough sugar. Covering up any of these undesirable flavors with fine flavoring produced no good results, especially with vanilla. The selection of flavoring is governed by a desire for quality and the need for economy. The author gives the following advice: (1) Do not guess when using flavor, (2) Measure accurately the amount of flavor used, (3) Confide in the supplier of flavoring, (4) Flavor makes or loses repeat sales, and (5) If flavor is worthwhile, then use the best. O.F.G.

926. "Wave" Flavors for Ice Cream. J. SHEURING, Univ. Illinois, Urbana, Ill. Canad. Dairy and Ice Cream Jour., *20*, No. 6: 18. 1941.

"Wave" or "ribbon" ice cream has come into prominence in the last two years and consequently has developed problems of manufacture. Settling of the "wave" flavor may be avoided by (1) having the ice cream as firm as possible consistent with good overrun as it leaves the freezer, (2) having as high viscosity in the flavoring syrups or gels as the pressure pump will handle satisfactorily, (3) having the flavoring material cold when added to the ice cream, (4) hardening the ice cream as rapidly as possible, and (5) maintaining the temperature of the distributing cabinets at a low point. Iciness may be avoided by (1) keeping the temperature of the flavoring material as low as possible without causing inconvenience in

handling, (2) keeping the concentration of the solids content of the flavoring material 40 per cent or above, and (3) maintaining the hardening temperature at a low temperature. Specifications and formulas are given for maple flavored syrups and gels, chocolate flavor, and fruit-flavored syrups.
O.F.G.

MILK

927. Saving Dollars in Your Plant. A. C. DAHLBERG, New York State Agr. Expt. Sta., Geneva, N. Y. Milk Dealer, *30*, No. 9: 102–104. June, 1941.

Losses were determined in eight plants which received an average of 62,442 pounds of milk containing 2,148 pounds of butterfat. The average daily butterfat loss from the milk cans amounted to 2.5 pounds, which was approximately 0.1 per cent of all milk which was received. The total butterfat losses for the eight plants were 13.6 pounds per day. This is approximately 0.6 per cent of all the butterfat received. Figured on the basis of 25 cents per pound for butterfat, which is a very nominal cost, the total daily loss for New York State would amount to approximately $5,000. The author gives suggestions for reducing these losses. C.J.B.

928. Some Experiments with Papaya in Milk. J. H. NEWMARK, Pres., Merle Products Corp., Coconut Grove, Fla. Milk Dealer, *30*, No. 10: 40–42. July, 1941.

Results of experiments over a period of time, using papaya pulp and juice (homogenized and vacuum packed) in milk, have indicated that papaya would be an important ingredient in infant feeding (and for adults, too), especially where there is an acid curd vomiting or digestive disturbance in the assimilation of milk. C.J.B.

929. Refrigeration Requirements in the Processing and Marketing of Milk. KENNETH M. RENNER, Dept. Dairy Mfrs., Texas Technol. College. Milk Dealer, *30*, No. 10: 44–48. July, 1941.

A brief summary of experimental work showing the rapidity and efficiency of cooling milk and a comparison of ice refrigeration and mechanical refrigeration, especially with reference to cooling costs, is presented.
C.J.B.

930. New Developments in Milk Bottles. F. P. GASS, Glass Container Assoc. Milk Dealer, *30*, No. 10: 78–86. July, 1941.

A discussion of the ways in which the glass milk bottle is keeping the pace of progress in the dairy industry is presented. C.J.B.

931. Report of Committee on "Chocolate Milk." SARAH VANCE DUGAN, Louisville, Ky. Jour. Milk Technol., *4*, No. 2: 72. 1941.

Fourteen states reported that they have no standard law or regulation covering chocolate milk or chocolate drinks.

The laws vary for the other states, and these variations are given.

Inquiry was made of 30 manufacturers as to the composition of the products sold to milk plants for making "chocolate milk" or "chocolate drinks."

Reports regarding plant practices were obtained from 98 plants which were selling a "chocolate milk."

Four of the recommendations made by the committee are that "serious consideration should be given by states and municipalities to the need of more realistic definition of the product known as "chocolate milk" or "Chocolate Dairy Drink."

"The butterfat content of chocolate flavored milks should be determined by the state or local standard for whole milk reduced only by the addition of the syrup or powder."

"The bacterial standard of chocolate flavored milk products should be determined by the bacterial standards for milk." L.H.B.

932. Phosphatase Production in Dairy Products by Microorganism. B. W. HAMMER AND H. C. OLSON, Iowa State College, Ames, Iowa. Jour. Milk Technol., *4*, No. 2: 83. 1941.

Using the modified Scharer phosphatase test (short test) it was found that various organisms produce phosphatase in sterile milk. Some of those belonging to the genus Pseudomonos were the most active, these include *Ps. putrefaciens, Ps. nigrifaciens,* and *Ps. mephitica.*

In the Escherichia-Aerobacter group, certain cultures of the Aerobacter group gave positive reactions while the Escherichia cultures were negative.

Five cultures of *Oospora lactis* gave positive reactions.

All of the Streptococcus or Lactobacillus groups studied were negative.

Several other groups were also studied, most of which were negative.

No detailed study was made of the number of organisms required in a product to give a positive phosphatase value.

The organisms producing phosphatase in milk, also produced it in butter, both salted and unsalted; but production was slower in the salted.

In applying the phosphatase test to butter, consideration should be given to the fact that phosphatase production by organisms in butter during the relatively long, normal holding period is possible. An important point in this connection is the ability of various Pseudomonas organisms to grow at relatively low temperatures.

From a limited number of trials made with pasteurized milk cheddar cheese that were still negative after several months it was assumed that less

danger of phosphatase production was possible in cheese than in butter, due to the fact that most of the active phosphatase producing organisms encountered are sensitive to acid, and therefore would be less likely to grow in sufficient numbers to produce a positive test. L.H.B.

933. **Report of the Committee on Education and Training.** H. E. MILLER. Jour. Milk Technol., *4*, No. 2: 87. 1941.

Most of the older members of the International Association of Milk Sanitarians obtained their training from personal experiences. Now that milk sanitation and quality control is rapidly progressing, the demand for milk sanitarians is greater than the supply, and there is an appeal to educational institutions to supply them. However, there is a limit to the number of positions available, so that it would be impractical to establish a full academic course in milk sanitation. The tendency is for schools of veterinary medicine, sanitary engineering, public health, dairy husbandry or dairy technology to provide courses in the more specialized phases of milk sanitation.

Although there is an increasing number of men entering the "profession" as milk sanitarians who hold degrees, there is still a large proportion who do not. They also believe that tests should be standardized in order that methods used for collecting samples and the interpretations of the results be uniform. To this end they recommend a committee be appointed by the International Association of Milk Sanitarians to cooperate with a committee of the American Public Health Association. L.H.B.

934. **The Phosphatase Test in Canada.** C. K. JOHNS, Ottawa, Can. Jour. Milk Technol., *4*, No. 2: 98. 1941.

A tabulation of the use of the phosphatase test in Canada is given. L.H.B.

935. **Contribution a l'étude des emplois des aciers inoxydables dans les laiteries et les fromageries. (Contribution to the Study of Uses for Stainless Steel in Dairies and Cheese Factories.)** J. LEMOINE. Le Lait, *20*, Nos. 198, 199, 200: 528–531. 1940.

The common uses to which stainless steel is put in milk processing plants and cheese factories are listed. The mechanical and physical properties of 8–18 stainless steel are described and its ability to resist the action of organic acids, detergents and sterilizing agents pointed out. Stainless steel containers for milk preserved by the Hofius process are almost essential. O.R.I.

936. **The Reduction of Resazurin in Milk and Aqueous Solutions.** H. R. THORNTON, F. MCCLURE AND R. B. SANDIN. Univ. Alberta, Edmonton, Can. Canad. Jour. Res., *19*, Sec. B. 2: 39–48. 1941.

Resazurin and methylene blue were compared in milks in which the oxi-

dation-reduction potentials were also electro-metrically determined. In aqueous solutions at pH 1 resazurin gave a perfect two-step titration curve and was reversible. At pH 7 the dye gave evidence of decomposing.

The blue-red reaction is electropositive and the red-white reaction electronegative to the methylene-blue–methylene-white reaction. In milk the red-white reaction appears to poise the system rather strongly at that E_h level. The color attained at the end of one hour with resazurin in good quality milk depends upon the E_h set up by the dye and the milk and there is no evidence that the color developed is related to the number of bacteria in the milk. In poorer quality milks the test may have greater value. It is concluded that the action of resazurin in milk is not fully understood. O.R.I.

937. The Value of Food Inspection and Properly Trained Food Inspectors. A. J. SLACK, Univ. Western Ontario, London, Can. Canad. Pub. Health Jour., *32*, No. 7: 357–361. 1941.

Foods of animal origin are the chief field for the food inspector. Meat inspection requires fundamental training in anatomy, parasitology and bacteriology. Milk inspectors must be competent to interpret tests for herd disease in addition to being able to carry out most of the tests for milk quality. The food inspector of the future will be a liaison officer between the producer, retailer and medical health officer. O.R.I.

938. Pasteurization of Skim Milk and Whey by Direct Steam Injection. A. T. R. MATTICK AND W. A. HOY, Univ. Reading, England. Food Mfr., *16*, No. 5: 116. 1941.

A series of tests has been made to determine the bactericidal efficiency of an adaptation of the plate type heat exchanger for pasteurization of dairy by-products before return to the farm for stock feeding.

The principle of the new process is the direct injection of steam into the product as it leaves the heat exchanger. In treating milk or milk products for animal consumption the objects are similar to those for humans—there must be a maximum destruction of organisms causing spoilage, and minimum damage to the total nutritive value.

It is suggested to heat the milk to 175° F. and hold three seconds. This is sufficient to kill the general flora, including coliform organisms and *M. tuberculosis*. J.C.M.

939. The Cause and Prevention of Milkstone Formation. L. SHERE, Diversey Corp., Chicago, Ill. Canad. Dairy and Ice Cream Jour., *20*, No. 7: 22. 1941.

The amount of milkstone deposited, and its physical and chemical characteristics, depend upon such variables as the rate of flow, the rate of heating

or cooling, the amount of milk processed over a specific area of equipment, the composition of milk, the efficiency of everyday clean-up operations, the hardness of water, the water softening action of cleaners and sterilizers and the condition of the surface in contact with the milk. The major objections to milkstone are: (1) A source of high bacteria counts, (2) It is a good insulator of heat, (3) It may cause off-tastes and flavor, and (4) It is unsightly in appearance. Milkstone control consists of proper steps to minimize its formation and proper steps to remove its deposits. Steps for minimizing milkstone deposits are: (1) Rinsing with cold water after handling, (2) Thorough everyday cleaning, and (3) Sterilization with chlorine rather than heat. The method of removal to be used is dependent upon the type of milkstone; *i.e.*, whether it is due to a long series of deposits one piled on the other or whether it is due to a single day's operation. O.F.G.

940. It's the Voice of Milk. R. W. BROWN, Univ. Manitoba, Winnipeg, Man. Canad. Dairy and Ice Cream Jour., *20*, No. 7: 25. 1941.

This is a general article which discusses milk flavor (the voice of milk). According to the author abnormal flavors and odors in milk may be due to one or more of 5 causes which he lists as follows: (1) Deranged physical condition of the cow, (2) Consumption by the cow shortly before milking of strong-flavored feeds or weeds, (3) Absorption by the milk of odors, (4) Direct contamination of the milk with flavor-producing substances, and (5) Changes brought about by microorganisms. Ways and means of ameliorating or eliminating the causes of abnormal flavors are discussed. O.F.G.

941. Pasteurization and Milk By-Products. K. G. WECKEL, Univ. Wisconsin, Madison, Wis. Canad. Dairy and Ice Cream Jour., *20*, No. 7: 34. 1941.

Pasteurization of milk by-products differs from the pasteurization of milk in several respects. Not only is sufficient heat applied to destroy pathogenic organisms, but frequently to accomplish other purposes such as: (1) Development of a desired flavor, (2) Development of a physical property of body or plasticity. (3) Elimination of undesirable organisms other than pathogenic types, (4) To favor the solution of some ingredients, (5) Improvement in color, and (6) Production of desired texture. There are circumstances, however, during which the use of unnecessary amounts of heat injures the quality of the product by interfering with: (1) Desired enzyme reactions, (2) Bacteriological growth in the heated product, (3) Physico-chemical properties such as coagulability or firmness, and (4) Flavor. The pasteurization of such products as cultured buttermilk, cultured sour cream, chocolate milk, bottled cream, process cheese, cheese spreads and ice cream mix is discussed in order to illustrate the points listed above. O.F.G.

942. Principles and Problems of Short Time Pasteurization. G. E. WERST, The Creamery Package Mfg. Co., Chicago, Ill. Canad. Dairy and Ice Cream Jour., *20*, No. 7: 35. 1941.

The author describes the theory and operation of plate exchange heaters and the operation of temperature and flow controls. Continuous operation, without shutdown, gives the most satisfactory and economical results. Variation in temperature is no serious problem and maintenance of the exchange equipment is simple. The control system must be of the precision type.
O.F.G.

943. A Discussion of Homogenized Milk. L. K. CROWE, Univ. Nebr., Lincoln, Nebr. Canad. Dairy and Ice Cream Jour., *20*, No. 4: 46. 1941.

This is an article which summarizes the present knowledge about homogenized milk. O.F.G.

944. The Processing of Milk as a Health Problem. A. WILSON, Medical Health Officer, Saskatoon, Sask. Canad. Dairy and Ice Cream Jour., *20*, No. 4: 60. 1941.

"Certified milk" failed to satisfy public requirements because it was too expensive and it did not always protect against diseases being spread to the consumer. A perfectly clean milk was not always a safe milk. Physicians and pediatricians are now advocating the boiling of pasteurized milk for infants and some invalids. The emphasis for protection of milk supplies is now placed on the processing of clean milk so as to destroy infection rather than trying to keep the infection out of raw milk by inspection. It is as much the duty of municipalities and governments to provide safe milk as it is to provide safe water. The author lists a number of things the fluid milk industry should do to compete with evaporated milk and points out that advertising has played an important role in placing evaporated milk in its present prominent position with the consumer. O.F.G.

945. The Sanitary Management of the Milk Plant. H. TRANMAL, Wisconsin State Dept. Dairying, Madison, Wis. Canad. Dairy and Ice Cream Jour., *20*, No. 5: 72. 1941.

For good cleaning of equipment the aim should be to keep the milk solids in soluble form or to make them so with the aid of washing powders, water and proper temperatures. Drying and heating of residues on surfaces should be avoided. The presence of milk stone indicates carelessness. A successful procedure for cleaning dairy utensils is as follows: (1) Thoroughly rinse and scrub with cold water, (2) Scrub with a warm slightly slippery washing solution, (3) Rinse in clear water, (4) Rack the utensils and (5)

Sterilize just before milking time with a chlorine solution. Special precautions should be taken in cleaning tinned copper equipment to prevent metallic and oxidized flavor in milk. O.F.G.

946. **Factors Influencing the Flavor of Milk.** P. F. SHARP, Cornell Univ., Ithaca, N. Y. Canad. Dairy and Ice Cream Jour., *20*, No. 6: 26. 1941.

This article is mainly a review of the present knowledge of milk flavors. It discusses briefly the art and accuracy of flavor judging, the types of flavors frequently found in milk and some of the chemical reactions which produce certain of these flavors. The influence of processing and handling on flavor and the importance of milk deaeration as a means of preserving vitamin C and prevention of oxidized flavor are discussed. Deaerated milk has been kept for 3 to 4 weeks and maintained a flavor score of 21 to 22.5 without loss of vitamin C. Vitamin C is stable in deaerated milk even when exposed to sunlight. O.F.G.

947. **A Visible Method of Recording Sedimentation on the Farm.** JOSEPH BURNS, Schwartz Mfg. Co., Two Rivers, Wis. Milk Dealer, *30*, No. 9: 86–90. June, 1941.

In an attempt to bring about "dirt consciousness" in dairy farmers, eight manufactured-milk patrons were furnished with visible recorders for 12 spent filter discs. The filter discs were returned to the plant, where they were graded. The results were highly satisfying, as six of the eight patrons showed an improvement in the amount of sediment on the discs. This method is recommended as a means of improving the quality of milk. The farmer forms a habit of observing his spent filter discs and, as shown by the above results, will usually attempt to improve them. C.J.B.

948. **How to Measure Bulk Quantities of Liquids.** NEAL M. CARTER, Pacific Fisheries Expt. Sta., Prince Rupert, B. C. Food Indus., *13*, No. 4: 41–42, 89. 1941.

This article discusses ways to accurately determine the volume and weight of liquids in tanks of different shapes. Temperature, distortion of container, effect of separated solids, froth and suspended bubbles must be taken into consideration. The results apply well to milk and cream.

As a unit of capacity the present U. S. gallon is the old English Queen Anne wine gallon, whereas the present Imperial is defined as ". . . the volume of 10 pounds avoirdupois of pure water, as weighed in air against brass weights, the water and air being at the temperature of 62° F. and the barometer at 30 inches."

Considerable exactitude is demanded in the control of certain processes in modern industries in order that standards and uniformity of quality may be maintained. However, commercial transactions and technological processes involving liquids frequently call for the handling of quantities too great for convenient direct determination in terms of weight.

One method of determining the weight of a bulk quantity of liquid is to attach a pressure-measuring device to the bottom of a tank having vertical sides. The gage reading in lbs./sq. in., multiplied by the tanks horizontal cross sectional area in sq. in. gives the number of pounds of liquid in the tank irrespective of any expansion or contraction of the liquid. Appreciable congealing or accumulation of solids at the bottom of the tank, may lead to failure of this method.

The indirect method, expression of volume or capacity in terms of weight is more generally used. It consists of most or all the following steps: (1) Determination of volume, (2) Measurement of temperature of liquid, (3) Expression of volume under standard conditions, (4) Application of conversion factor to change volume to weight. Tables and examples are given. J.C.M.

949. The Past and Future of Dairying. H. A. RUEHE, Univ. Illinois, Urbana, Ill. Jour. Milk Technol., *4*, No. 2: 78. 1941.

A brief history of dairying in Illinois, origin of the Chicago Milk Shed, and of the cheese, butter and evaporated milk industry in the state is presented.

Comparisons are made with present conditions. Competitive development of dairying in other sections is discussed, as are trade barriers and changing age levels, and their probable effect on the future of dairying.

L.H.B.

PHYSIOLOGY

950. Some Morphological and Functional Relationships of the Bovine Hypophysis. L. O. GILMORE, W. E. PETERSEN AND A. T. RASMUSSEN, Minnesota Agr. Expt. Sta. Tech. Bul., 145. 55 pp.

An interesting account of original studies on the morphology and histology of the bovine hypophysis (pituitary). Data were obtained from 139 females and 62 males of known origin. Observations and conclusions were:

The development of the bovine hypophysis from the fetal stage to maturity may be expressed by the shape of a sigmoid curve.

At birth the hypophysis is about .45 gram for females and .5 gram for males, although the range is from .3 to .7 gram for females and .4 to .8 gram for males.

The gland increases rapidly in size for the first three to four years, after which there is a decreasing rate of increase. In males the rate of increase decreases less rapidly than in females.

While the period of greatest size increase in the hypophysis corresponds to the period of greatest increase in body size, the hypophysis increase is much slower, as shown in comparing the weights of both hypophysis and body for given periods, to their respective birth weights.

The weights of hypophyses from freemartins tend to be smaller than for normal females. In part, at least, this is accompanied by smaller body weights.

No relationship between the relative hypophysis weight and producing ability is evident.

The shape as well as the weight of the bovine hypophysis varies markedly.

Distinct differences in the proportional weight of the anterior lobe are found between groups of the bovine. Whether that is due to inheritance or age could not be determined from the data at hand.

The presence of a cone of Wulzen does not appear to be limited by breed or sex, or to any particular post natal age.

The intermediate lobe in the bovine is exceedingly wide compared to that in humans.

In addition to the three ordinarily described types of cells (acidophiles, basophiles, and chromophobes) in the anterior lobe, the acidophiles were divided into two classes—crimson and brick-red acidophiles.

The presence of the crimson acidophile appears to be associated with sexual activity as in other species.

Differential cell counts indicate that there may be some difference between the bovine and some other species (cat, pigeon, and possibly the human).

No castration effect on proportional cell distribution in cattle was noted, but too few animals are involved to make this certain.

No nerve fibers were found in the anterior lobe of one bovine gland, but they were very abundant in the neural lobe and plentiful in the *pars intermedia.*

The text is well supplemented with tables, graphs, and illustrations. There is an extensive review of the literature based on a bibliography of 89 references. J.G.A.

951. The Transfer of Radioactive Sodium Across the Placenta of the Goat. HERBERT A. POHL, LOUIS B. FLEXNER AND ALFRED GELLHORN, Dept. Embryology, Carnegie Inst. of Washington, Baltimore, Md. Amer. Jour. Physiol., *134:* 338–343. 1941.

The rates of placental transfer per unit weight of placenta have been

measured with Na^{24} from a gestation age of about nine weeks until term. There is a three- or four-fold increase in transfer rate from the ninth week to about the nineteenth and twentieth weeks of pregnancy.

The placenta of the goat belongs to the syndesmochorial group. Its rate of transfer of Na^{24} per gram of placenta is of the same order of magnitude as that of the endotheliochorial placenta of the cat at comparable stages of pregnancy.

As pregnancy advances, there is a tendency for the tissue layers of the cotyledonary areas to be reduced to a degree commensurate with the increased nutrient requirement of the fetus. D.E.

952. Cortilactin, The Lactation Factor of the Adrenal. HERBERT S. SPOAR, FRANK A. HARTMAN AND KATHARINE A. BROWNELL, Dept. Physiol., Ohio State Univ., Columbus, Ohio. Amer. Jour. Physiol., *134:* 12–18. 1941.

A lactation factor was prepared from the adrenal which possessed about one-tenth of the potency of purified prolactin when tested by the crop gland method. The daily injection of 1 mgm. cortilactin preparation into an adrenalectomized rat maintained on cortin enabled her to lactate normally. D.E.

MISCELLANEOUS

953. Sweet Water Systems. ANONYMOUS. Milk Dealer, *30,* No. 9: 124–125. June, 1941.

Milk dealers using sweet water systems are apparently in the minority, it is indicated by reports received from a selected group of distributors in 16 states. The question, "Are you using a sweet water system" brought a negative answer from 67.3 per cent of the dealers replying, while 32.7 per cent advised that they were at present using a sweet water system.

The questions: "What capacity are you using?" "What capacity would you require?" and "How many uses do you have for cold water in your plant?" brought a wide variation in replies. C.J.B.

954. Cathodic Control of Corrosion. R. W. WARNER, Univ. Texas, Austin, Texas. Ice and Refrig., *100,* No. 5: 354. 1941.

After a discussion of the electrolytic theory of corrosion, the author suggests methods for the prevention of corrosion to ice making tanks, piping and ice cans. The results of experimental work in connection with the use of protection anodes are described. The system of protection requires that current be taken from the metal part being protected to an external source of voltage. It is connected to the negative side of this source. From the

positive terminal of the source current is taken to the artificial anode and back to the brine solution from which it flows into the parts being protected. The electrical connections are such that the part being protected is made more negative to the solution than it was before, so that there is a positive tendency for current to flow toward the metal. The magnitude of the voltage must be just enough to insure current flow from the artificial anode to the cans, coils, and tank. The anode will be eaten away and must be replaced at intervals. A zinc anode is found to be very satisfactory. Cost figures for this system are included. L.C.T.

955. The Profitable Operation of Locker Plants. F. J. MOHER, Editor, "Meat Merchandising," St. Louis, Mo. Canad. Dairy and Ice Cream Jour., *20*, No. 5: 62. 1941.

This is an inspirational article dealing with ways and means of obtaining and retaining business in the profitable operation of a cold storage locker plant. O.F.G.

956. Walls and Ceilings from the Sanitary Standpoint. L. C. THOMSEN, Univ. Wisconsin, Madison, Wis. Canad. Dairy and Ice Cream Jour., *20*, No. 5: 74. 1941.

Light colors are recommended for the ceilings and upper walls because the lighter colors reflect more light and create better visibility. Experts recommend lighting of approximately 2 watts per square foot of floor space. Paint is important from the standpoint of sanitation. Mold infected walls may be cleaned by washing with trisodium phosphate, drying, washing with chlorine solution and again drying. Special paints containing fungicides are now available. The use of titanium oxide and high strength lithopones minimizes discoloration in white paints. The chief cause of paint peeling is accumulation of moisture between the paint and wall. Tan or buff colored glazed tile or brick have appealed to dairymen because they are harder, give better wear, do not soil as readily, are easier on the eyes and cost less than white brick. O.F.G.

957. Quick Frozen Foods in Lockers. J. H. L. TRUSCOTT, Ontario Agr. College, Guelph, Ont. Canad. Dairy and Ice Cream Jour., *20*, No. 6: 74. 1941.

The size of ice crystals in the flesh of fruits, vegetables, meats, etc., is indirectly proportional to the rate of freezing. When the crystals are too large, the cells are punctured and torn and lose their contents later when they are thawed out. Rate of freezing depends largely on the size of the object to be frozen. Freezing directly in the locker itself is impractical. Processing of vegetables and fruits previous to freezing is important.

Water-tight packages are essential. It has been found that frozen fruits retain a large proportion of their vitamin C but variable results have been obtained with vegetables. Although all the facts are not known there are indications that: (1) properly frozen products retain food values at least as well as any other method of preservation, and (2) vitamin C losses may be considerable during a 4-month storage period at any temperature above zero. Bacteria, molds and yeasts are reduced in numbers by from 50 to 90 per cent by freezing. O.F.G.

958. Use of Concrete in Dairy Plant Construction. HUGH R. ROBERTS, Portland Cement Assoc., Atlanta, Ga. Milk Dealer, *30*, No. 9: 54–58. June, 1941.

A discussion is given of the role which concrete can play in dairy plant construction. The proper use of concrete in such construction is discussed. C.J.B.

959. Problems of Brine Control. FRANK PHILABERT, Chemical Solvent Co., Birmingham, Ala. Ice and Refrig., *100*, No. 3: 203. 1941.

There are two steps in the handling of brine, (1) its preparation and (2) its maintenance. For its preparation a soft water free from silt and suspended matter should be used. A water which is good enough for drinking or ice making is suitable.

When calcium chloride is dissolved in water it is ionized into calcium and chlorine ions. The water reacts with these ions to form calcium hydroxide and hydrochloric acid. The reaction, however, immediately reverses itself. A mildly acid condition nevertheless is inclined to result. If foreign matter is present the equilibrium is upset and corrosion results. Hydrogen then is given off and dissolves in the brine, thus reducing the hydrogen ion concentration and making the brine more acidic. The addition of an alkali is a temporary remedy only, since it increases the concentration of foreign matter, and brings about side reactions. If chromates are used, the dichromate should first be converted into a chromate before use.

Ammonia leaks into brine are particularly bad from a corrosion standpoint. The ammonium hydroxide which forms, reacts with the calcium chloride to form ammonium chloride and calcium hydroxide. Since the calcium hydroxide settles out the brine is weakened. The ammonium chloride hydrolyzes and hydrochloric acid and additional ammonium hydroxide is formed. Again the brine becomes acidic unless ammonia continues to leak into the brine. In general the situation results in a very corrosive brine. The addition of hydrochloric acid to a brine which contains ammonia should be discouraged.

Brines should be checked periodically and properly treated when neces-

sary. Sediment should be removed by filtration, and the brine should always be maintained in a clear condition. L.C.T.

960. The Selection, Installation and Operation of Automatic Controls. A. B. SCHELLENBERG, Alco Valve Co., St. Louis, Mo. Ice and Refrig., *100*, No. 4: 284. 1941.

Advantages in the use of automatic controls for refrigeration systems are cited. Practical operating illustrations of their value are given. A number of automatic valves are described such as the thermostatic expansion valve, the multi-outlet valves, float valves, magnetic valves and evaporator pressure controls. Pictures and diagrams of these valves as well as installation diagrams are included. L.C.T.

961. Problems of Frozen Food Locker Plant Operation. ALFRED CORY. Ft. Atkinson, Wis. Ice and Refrig., *100*, No. 3: 243. No. 4: 313. No. 5: 389. No. 6: 463. 1941. *101*, No. 1: 129. 1941.

This series of articles discusses the frozen food locker plant operation from a managerial standpoint. Emphasis throughout the series is on accounting, and forms are illustrated and methods described. The articles should be especially helpful to those who are just venturing into the frozen food locker business but they likewise contain excellent information for those with more experience. Some emphasis is placed on points to be observed in order to make the undertaking a successful one. L.C.T.

962. Safety in the Refrigeration Industry. JOHN M. ROCHE, Industrial Safety Engineer, National Safety Council. Ice and Refrig., *100*, No. 6: 420. 1941.

Various accidents and means for their prevention in the refrigeration industry are listed. Slips and falls are most often the result of the following unsafe conditions:

(a) Defective or wet and slippery floors.
(b) Improper illumination.
(c) Defective stairs, ladders, ramps and scaffolds.
(d) Running instead of walking.
(e) Carrying loads or pushing trucks so as to obstruct vision ahead.

Strains and sprains resulting from industrial accidents indicate that the majority of them are due to the following:

(a) Improper assignment of individuals predisposed to sprains and hernias to heavy manual labor.
(b) Lifting too great a load unassisted.
(c) Handling loads with poor footing.
(d) Lifting too hastily, or carrying loads improperly.
(e) Showing off.

Injuries due to handling tools were found to result from:

(a) Using wrong tool for the job.
(b) Defective tools.
(c) Using defective tools such as shimming an oversize wrench.
(d) Using correct tool improperly, such as pushing on a wrench or placing an extension handle on a wrench.
(e) Using tools while in an unsafe position, or in such a manner as to create a hazard (using tools on pipes or apparatus under pressure). L.C.T.

963. A Democratic Industry under War Time Conditions. A. L. GIBSON, Eastern Dairy School, Kemptville, Ont. Canad. Dairy and Ice Cream Jour., *20*, No. 4: 32. 1941.

This is a discussion of the part the dairy industry must play in war-time economy and the need for orderly planning of the whole industry so that it can be efficiently conducted under such conditions. O.F.G.

964. The Comparison of Odors. H. D. RENNER. Food Mfr., *16*, No. 6: 131. 1941.

An apparatus has been devised which can be used as an aid in comparing intensities of odors. This apparatus was originally devised as a means of testing the olfactory powers of human beings.

The principal element of the apparatus consists of gas washing bottles made of brown glass, in which is placed the materials to be tasted. By means of bellows and a tube in the bottle air with a definite odor can reach the nose of the observer. J.C.M.

965. A Bacteriologic Study of a New Sanigenic Flooring. W. L. MALLMAN, Mich. State College, East Lansing, Mich. Jour. Amer. Med. Assoc., *117*, No. 10: 844. 1941.

An investigation was made of the effect on microorganisms of using "hubbellite," a new cement floor surfacing material containing cupric oxychloride. The manufacturers claim that this flooring, when wet, releases a minute amount of a copper compound which exerts an oligodynamic action on bacteria in the water film on the floor surface. It was found that lethal effects were obtained when bacteria and molds were smeared on hubbellite tiles in the absence or presence of organic matter, and that under comparative conditions hubbellite flooring showed lower bacteria and mold counts than ordinary concrete floors. D.P.G.

966. Food Machinery for South America. H. GORDON LAWSON JOHNSTON. Food Mfr., *16*, No. 4: 81. 1941.

During World War I the South American countries were growing rich from their sale of wheat, meat, and hides to Europe for the Allies.

After the war Argentine and Brazil started to study and develop the manufacture of food at home. The industry received full support of the government so it was soon a thriving condition.

This article tells how the branch agents should cooperate with the home office in selling of machinery and good will. J.C.M.

967. The Control of Color in Food Processing. H. W. RUDD, London, England. Food Mfr., *16*, No. 6: 129–130. 1941.

It is a known fact that the majority of people buy foods somewhat by their color. It is the job of the manufacturer to give the public what it desires.

The preservation of color during processing all types of foods comes under three heads: (1) changes occurring during the actual cooking; (2) changes during storage; (3) methods of assessing and standardizing color changes.

During storage color changes may be due to (1) natural metabolic processes, (2) interaction between food and material of container, (3) action of sunlight (usually results in fading). J.C.M.

968. Nitrate Kills Odor in Waste. N. H. SANDBORN, Natl. Canners Assoc., Washington, D. C. Food Indus., *13*, No. 4: 57–58, 101. 1941.

Studies on the nitrate treatment of lagooned wastes were not undertaken as the development of a new method for treating cannery wastes but rather as a corrective measure for those lagoons now in existence which are so located as to produce an odor nuisance.

The ability of nitrates to prevent putrescence in domestic sewage was recognized in 1892.

It is well known that organic matter in solution rapidly depletes the water of its oxygen content. When this condition is obtained the organic matter undergoes anaerobic decomposition with the production of offensive odors. By supplying an available source of oxygen the organic matter may be made to decompose without odor formation. Nitrates furnish such a supply of oxygen.

The following conclusions were drawn after tests were made with nitrate: (1) It is not practical to treat all wastes; (2) At a 40 per cent dosage rate satisfactory odor control is possible; (3) Partial odor control is possible with a 30 per cent dosage rate.

It is believed that the use of sodium nitrate at lower dosage rates starting at the time the disposal plant begins to operate would prove to be more effective. J.C.M.

969. After the War—What of Agriculture? R. MCQUEEN, University of Manitoba, Winnipeg, Man. Canad. Dairy and Ice Cream Jour., *20*, No. 5: 36. 1941.

The first part of this article deals with the development and early eco-

nomic history of Canada up through the last World War to 1919. The problems and burdens of prosecuting the last World War are contrasted with those being encountered in carrying on the present conflict. The farmers of western Canada are faced with the problem of a great wheat surplus and consequently must change their crops or accept a decrease in standards of living. If, after the war, international trade revives, a change may not be necessary. If a change is necessary the author believes the raising of hogs and the production of dairy products possess the greatest comparative advantage next to wheat for western Canada. O.F.G.

970. The Disposal of Dairy Wastes. H. A. TREBLER, Sealtest Res. Lab., Baltimore, Md. Jour. Milk Technol., *4*, No. 2: 93. 1941.

The essential thing is to cut down waste in the plant to the least possible amount. Small amounts of milk wastes are not detrimental, and may even be beneficial to healthy stream conditions providing the reaerating ability of the stream is great enough.

In some cases the amount of water in the stream used for disposal is great enough during a portion of the year so that treatment will not be necessary.

If complete treatment is necessary, it is recommended that one of the well-established firms which are now specializing in dairy waste disposal be consulted. L.H.B.

971. Low Pressure Boilers for Dairy Plants. DAVID BURKE, Elm Farm Dairy, Albany, N. Y. Milk Dealer, *30*, No. 10: 35, 66–67. July, 1941.

The author discusses the following advantages of low-pressure boilers: Reduced labor costs, less space required, fully automatic, lower initial cost, and elimination of high-pressure steam leaks in pipe lines and the burning out of valve seats on valves used to control and throttle steam for hose lines. C.J.B.

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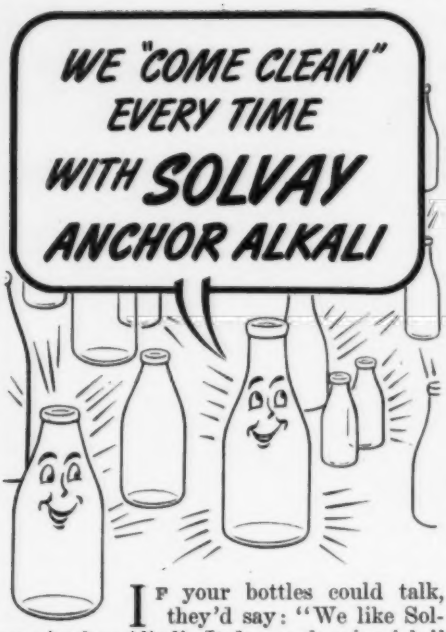

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